DELIVERABLE (COMBINED 235A, 236A, AND 235E, 236E)

TREATABILITY STUDY REPORT

AND PROCESS FORMULATION REPORT

FOR

POND 207C AND CLARIFIER

REVISION 0

HALLIBURTON NUS ENVIRONMENTAL CORPORATION
PITTSBURGH, PENNSYLVANIA 15220

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EXECUTIVE SUMMARY

The work described in this report was conducted in support of the Waste Processing project for the Solar Ponds, Pondcrete, and Saltcrete. This report has been prepared by HALLIBURTON NUS Environmental Corporation in support of the Solar Pond Remediation Contract (EG&G Subcontract Number PC84017JB).

The Treatability Study Report describes the requirements, procedures, and the results for the testing conducted to develop a chemical stabilization and solidification formula for Solar Pond 207C contents and the Clarifier contents. All testing of the Rocky Flats waste was conducted in the HALLIBURTON NUS Treatability Study Laboratory in Pittsburgh, Pennsylvania.

Pond 207C contains approximately 500,000 gallons of high salt waste that is classified as a low-level mixed waste. The contents of the pond are in three phases; water, crystal, and silt/sludge. The Clarifier tank contains approximately 27,000 gallons of sludge and water and is also classified as a low-level mixed waste. Both the Clarifier and Pond 207C are listed hazardous waste for waste codes F001, F002, F003, F005, F006, F007, and F009. Both are also a characteristic hazardous waste for toxicity of cadmium (Waste Code D006). Pond 207C is a characteristic hazardous waste for toxicity of arsenic and chromium, which corresponds to the D004 and D007 waste codes.

The goal of the treatability study was to develop a chemical stabilization and solidification (CSS) formulation that produces a final product that passes all regulatory certification requirements and the Nevada Test Site (NTS) acceptance criteria as specified in the "Nevada Test Site Defense Waste Acceptance Criteria, Certification, and Transfer Requirements", NVO-325. Although there is no certification requirement for durability testing, considerable effort was devoted to wet/dry and freeze/thaw durability testing because of the likelihood that the stabilized waste may be stored at Rocky Flats for an extended period of time until ultimate disposal at NTS.

The general concept used for developing the CSS formula followed a progression from screening binder/waste formulations through a more comprehensive evaluation of variables. The experiments used to develop the CSS formulation were conducted using factorial experiments, which allow independent evaluation of the effect on one variable from the interaction of other variables. The treatability study was conducted in phases. The initial testing (Phase I/II) used factorial experiments to evaluate the interaction of cement and flyash by varying the dosage of each.

Several experiments were also designed to evaluate various additives to improve long-term durability. Phase III/IV testing consisted of experiments designed to determine an operating envelope in which the CSS formulation produced a final product that achieved all regulatory and acceptance criteria.

The selected CSS binder formulation for Pond 207C and Pond 207C/Clarifier waste includes Type V portland cement, Type C flyash, and hydrated lime. Halliburton Services Latex 2000 System can be added to improve matrix resistance to environmental changes (freeze/thaw and wet/dry). The target pozzolan blend of cement, flyash, and lime is 1.0/2.0/0.075 on a weight ratio basis. If latex is added, the target dosage is 5 percent by weight of the cement. Testing indicated that the CSS formulation is not extremely sensitive to the ratio of these components, which can vary considerably from the target ratio and still successfully achieve all regulatory criteria and NTS acceptance criteria.

Key operating parameters for the CSS process include waste loading and the water to pozzolan ratio. The treatability study defined an operating envelope for each of these parameters. Operating within the envelope will produce a product that should meet all acceptance criteria. The target water to pozzolan ratio is 0.42, but successful results were obtained over an operating range of 0.34 to 0.56 for 207C waste, and 0.34 to 0.50 for the combined 207C/Clarifier waste.

During remediation, the process will be controlled by monitoring the input and output slurry specific gravities. The input specific gravity corresponds to a total solids and water content, which at a specified water to pozzolan ratio, determines the required specific gravity of the output. The radioactive densometer on the Halliburton Recirculating Cement Mixer continuously monitors the output specific gravity and makes any necessary adjustments to the pozzolan feed, as required, to maintain the output specific gravity to within 1 percent of the set point.

It can be concluded from the treatability study results that if the operating envelope is controlled to the prescribed criteria, then the waste product should achieve the following:

- Pass all LDR requirements for F001, F002, F003, F005, F006, F007, and F009 listed wastes as regulated by 40 CFR Part 268.

- Pass the requirements for characteristic wastes by toxicity for D004, D006, and D007 as regulated by 40 CFR Part 261.

- The final waste form will be considered a solid as determined by the Standard Test Method for Determining Whether a Material is a Liquid or a Solid (ASTM D4359-84).

- The final waste form will have no free liquids as determined by the Paint Filter Liquids Test (SW846, Method 9095).

- The final waste form will achieve acceptable strength as measured by unconfined compressive strength.

1.0 PROJECT DESCRIPTION

This treatability study report describes the requirements, procedures, and results for the testing conducted to develop chemical stabilization and solidification (CSS) formulations for several waste sources at the Rocky Flats Plant. This work was conducted in support of the Solar Ponds/Pondcrete/Saltcrete Waste Processing project being conducted by HALLIBURTON NUS Environmental Corporation. The waste sources of concern that are discussed in this report are as follows:

- Solar Pond 207C sludge and water
- Clarifier sludge and water

The results for the treatability study conducted on the A and B Solar Pond sludges will be discussed in a separate document. Additionally, this report will primarily discuss the results of the final phase of the treatability study which represents testing conducted to ensure compliance with all RCRA Land Disposal Restriction (LDR) and free liquid requirements. Preliminary testing for the 207C Solar Pond and the Clarifier are discussed in the following documents, which are provided in Attachment A. A discussion of the preliminary testing is provided in Section 2.2.

- Memo to Ted Bittner from Tom Snare (January 20, 1991) Correspondence Number C-49-01-92-57 (Attachment A-1).

- Technical Memorandum, 207C Stabilization Results From Initial Phase of Testing, Revision 1, HALLIBURTON NUS, May 6, 1992 (Attachment A-2).

- Clarifier Memo, HALLIBURTON NUS, May 1992 (Attachment A-3).

- Memorandum, Cyanide Oxidation Test Results for Pond 207C, HALLIBURTON NUS, March 15, 1992 (Attachment A-4).

- Memorandum, Pond/Clarifier Sludge Geotechnical Data-Modified Method, HALLIBURTON NUS, May 13, 1992 (Attachment A-5).

The following sections contain the site history, project purpose, description of the remediation process, and description of the treatability study process.

1.1 AUTHORIZATION

This report has been prepared by HALLIBURTON NUS Environmental Corporation (HALLIBURTON NUS) in support of our Solar Pond Remediation Subcontract (EG&G Subcontract Number PC84017JB). The purpose of this report is to summarize the treatability study work conducted at the HALLIBURTON NUS Laboratory in Pittsburgh, Pennsylvania. This report provides supporting documentation for all treatment-related criteria required for certification of the final stabilized waste form.

This report is defined as Combined Deliverable Number 235A, 235E, 236A, and 236E, encompassing both the Treatability Study Report and the Process Formulation Report.

The Treatability Study Work Plan, Combined Deliverable 231A, 231B, 231C, and 231E (Draft 2) (HALLIBURTON NUS, September 1991) was provided to EG&G in September 1991. After an October 9th briefing of the proposed Treatability Work Plan in the EG&G offices in Golden, Colorado, a joint understanding between EG&G and HALLIBURTON NUS was reached that the scope of work may vary substantially during the course of conducting the Treatability Study because of the complexity of the work, and that no effort should be made to continually revise the Treatability Study Work Plan. Authorization to proceed with the treatability study work described within this report was provided verbally to HALLIBURTON NUS by EG&G,

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1.2 SITE DESCRIPTION

The Rocky Flats Plant is located approximately 16 miles north west of Denver, Colorado in northern Jefferson County. The facility is located on 6,550 acres with the main production facilities located within a fenced security area of 384 acres. Figure 1-1 provides an area map. The area immediately surrounding the Rocky Flats Plant comprises a combination of agriculture, open space, industry and low-density residential housing.

1.2.1 <u>Background</u>

The Rocky Flats Plant began operations in 1952 and its primary purpose was to produce nuclear weapons components. The weapons components are fabricated from plutonium, uranium, beryllium, and stainless steel. Production activities

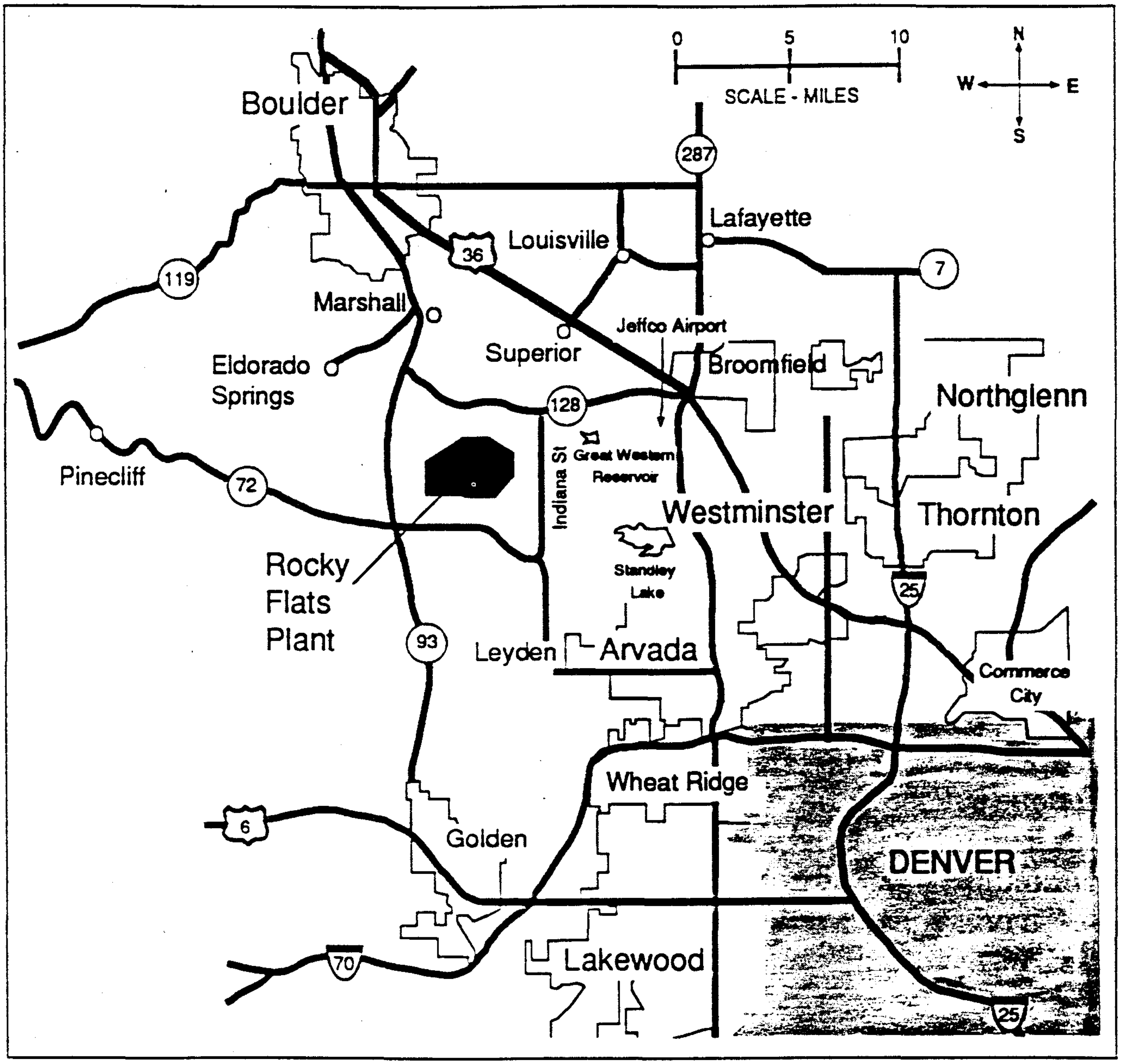

Figure 1-1. Area Map of RFP and Surrounding Communitie

include metal fabrication and assembly, and chemical recovery and purification of process-produced transuranic radionuclides (EG&G Rocky Flats, 1990).

During construction of the Rocky Flats Plant, a solar evaporation pond was installed. The pond was designed for the impoundment of aqueous waste products discharged from the Process Waste Treatment Plant. The waste contained high levels of chemical contaminants, such as fluoride, nitrates, and various metallic ions. As a result of changing plant operations and environmental requirements, additional evaporation ponds were constructed. Occasionally, these ponds were used for the disposal of untreated waste products, such as metallic lithium, acids, sewage sludge, plating residues, and several other wastes. Sewage effluent has been reported to have been stored in the pond since 1977 (Wienand, 1992).

Five solar evaporation ponds, designated ponds 207A, 207B (north, center, and south), and 207C, are located in the northeast corner of the plant as shown in Figure 1-2. The solar ponds were constructed to store and evaporate much of the process wastewater generated at the plant. The five ponds are currently being closed under RCRA.

1.2.2 Pond 207C

Pond 207C covers approximately 0.87 acres. The contents of the pond are classified as low-level mixed waste. The pond contains high salt concentrations which approach saturation levels. The pH of the pond ranges between 10 to 11 S.U.

Pond 207C consists of three distinct interfaces; pond water, silty sludge, and crystals. The pond water overlies the crystals, which in turn overlies the silty sludge. The pond water is a golden color, with a few black flecks noted in what was otherwise described as a low turbidity liquid (HALLIBURTON NUS March, 1992). Data obtained from recent sampling also shows that the water layer is stratified, with denser brine at the bottom strata and more dilute brine at the surface. The solution color changed noticeably with depth. The volume and density of the pond water apparently varies depending on precipitation, evaporation, and temperature values. The crystal layer ranges in thickness depending on the temperature of the pond. The crystals have had a consistency of rock salt and/or well-defined crystals with a shape similar to a parallelogram (approximately 2 cm long and several millimeters thick). The crystals have a yellowish to greenish tint

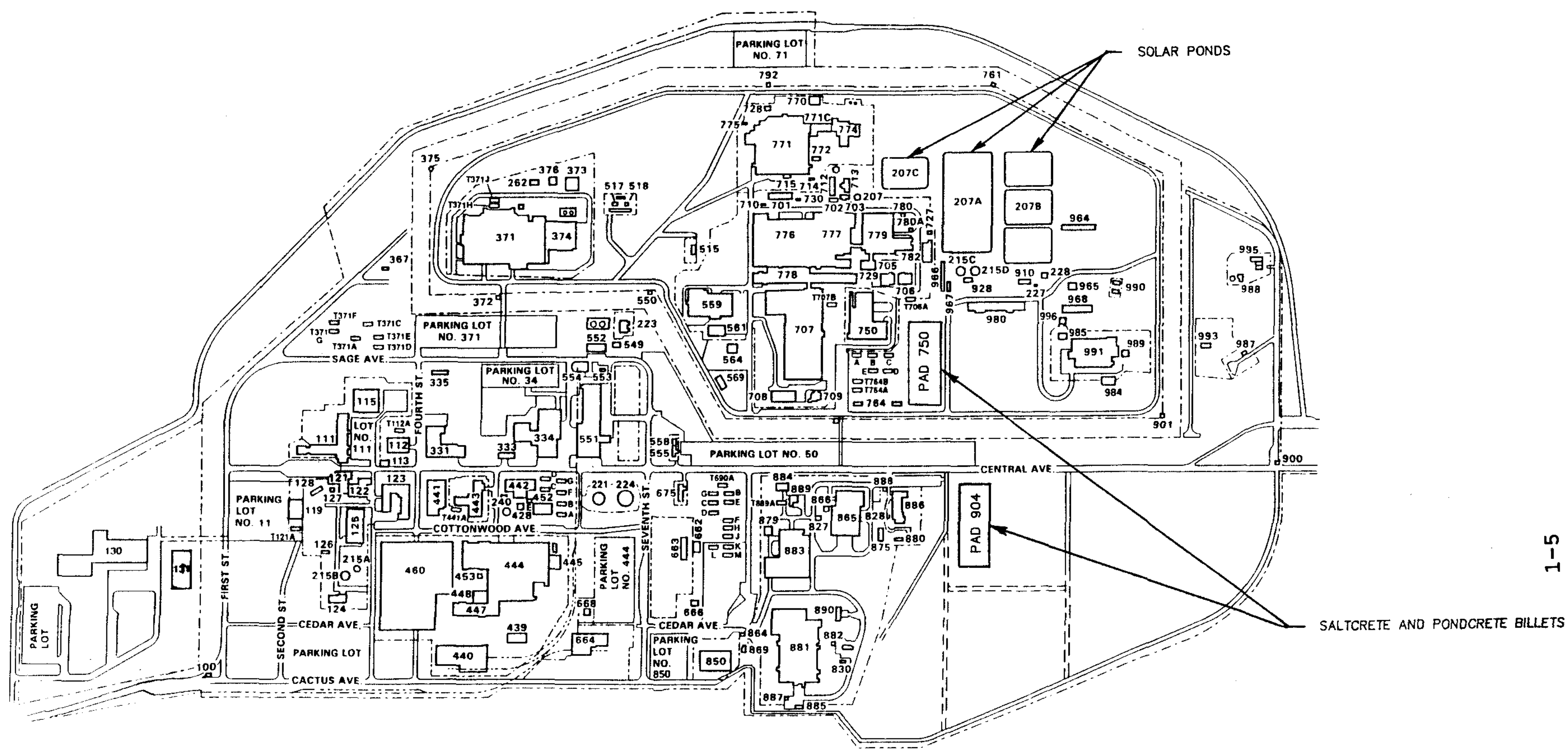

FIGURE 1-2

ROCKY FLATS COMPLEX
ROCKY FLATS, GOLDEN, COLORADO

NUS CORPORATION

depending on the sampling location. The silty sludge is fine-grained and has a green color.

The following volumes of liquid and solids phases were estimated from the depth sampling activities conducted in April 1992, using an earth moving calculation program called EARTH 3.

Water	387,300 gallons
Crystal	61,100 gallons
Silt/Sludge	38,800 gallons

1.2.3 Clarifier

The clarifier is a 25-foot diameter tank located between Pond 207A and Pond 207C. The clarifier was used in the previous pond cleanout to thicken pond sludge prior to mixing with cement. The clarifier tank contains approximately 27,000 gallons of sludge and water derived from Pond 207A. This material, which is also classified as a low-level mixed waste, was placed in the clarifier when the pond sludge was being treated to generate pondcrete. The water in the clarifier is yellow/green to brownish in color, with a few black solids noted. Otherwise, the water is relatively clear with low turbidity.

Depth measurements of the clarifier contents were completed in May of 1992. Based on the data taken and the clarifier dimensions, the following volumes of liquid and sludge were calculated.

Solution	15,000 gallons
Sludge	11,880 gallons

1.2.4 Prior Removal and Remediation Activities

Rocky Flats began phasing out use of the solar evaporation ponds in the early 1980s because of environmental concern. The plan for cleanup of the ponds was to drain and treat the liquid waste and to mix the pond sediments/sludges with cement. The resulting solidified material, called pondcrete, was to be disposed of at DOE's Nevada Test site (NTS).

Cleanout of the largest surface impoundment (Pond 207A) began in 1985. The sludge from the bottom of the pond was pumped to the clarifier where it was allowed to settle before being pumped to a pugmill. Cement was added to the sludge and mixed to a desired consistency in a pugmill. The pondcrete mixture was then fed through a chute into lined triwalls. It is assumed that improper mixing of cement and sludge resulted in some Pondcrete blocks that did not solidify properly and, therefore, crumbled and cracked during storage.

Since the discovery of the pondcrete problems in May 1988, Rocky Flats has not cleaned up any additional sediment from the solar ponds. Currently, the clarifier contains approximately 27,000 gallons of water and sludge that remained from the original pondcrete solidification project.

1.3 WASTE SYSTEM DESCRIPTION

This section provides details on the waste matrix with regard to chemical constituents. The information provided has been excerpted from the Pond Sludge Waste Characterization Report (Deliverable 224A and 224E, HALLIBURTON NUS, March 1992) and the characterization data for the bulk samples used for treatability testing.

1.3.1 Analytical Program

The sampling activities to chemically characterize the waste forms were conducted in August 1991 by EG&G personnel under supervision by HALLIBURTON NUS personnel. Additional samples were collected in October 1991 to provide geotechnical data for engineering design. The purpose of the sampling was to provide an analytical baseline for each waste form that was to be remediated.

The analytical program was developed based on the analytical requirements of the applicable listed EPA waste numbers for the solar ponds, and also by those engineering parameters which may be of concern to the solidification treatment process. The EPA waste codes, provided by EG&G, are shown in Table 1-1.

TABLE 1-1

EG&G WASTE CODE IDENTIFICATION LIST

Hazardous Waste Code	Description
F001	Spent halogenated solvents used in degreasing
F002	Spent halogenated solvents
F003	Spent nonhalogenated solvents
F005	Spent nonhalogenated solvents
F006	Wastewater treatment sludges from electroplating operations
F007	Spent cyanide plating bath solutions from electroplating
F009	Spent stripping and cleaning bath solutions from electroplating operations where cyanides are used
D006	RCRA waste for the characteristic of toxicity for cadmium

The LDR constituents associated with the above EPA hazardous waste codes were analyzed during the waste characterization program. The laboratory analytical program for pond waters and sludges is summarized in Table 1-2.

The organics that were analyzed consist of those compounds for which numerical standards have been developed as part of the Land Disposal Restrictions (LDRs) for hazardous waste numbers F001, F002, F003, and F005. These compounds are shown in Table 1-3. The analytes include volatiles, semivolatiles, and several alcohols.

Metals analysis was conducted for both waste forms and includes those metals regulated by 40 CFR 261.24 (toxicity characteristic), plus nickel and boron. Total metal content and TCLP analysis were performed for each parameter. The toxicity characteristic metals were analyzed for regulatory purposes; nickel was analyzed because it is a constituent of F006 and F009-type wastes (electroplating wastes). Boron was analyzed because it can interfere with cement chemistry. Cyanide was analyzed because it is a constituent of F006 and F009-type wastes.

Both aqueous and solid wastes were analyzed for ammonia and total organic carbon. Both of these parameters can affect cement chemistry.

TABLE 1-2

ROCKY FLATS
WASTE CHARACTERIZATION ANALYTICAL METHOD LIST
POND 207C AND CLARIFIER

Analysis	Method: Sludge	Method: Liquid/Extracts
Chemical Characterization		
• Selected VOAs(1)	SW 8240	SW 8240
• Selected Semivolatiles(2)	SW 3550/8270	SW 3510/8270
• Selected Alcohols(3)	ASTM D 3695-82	ASTM D 3695-82
• Arsenic	SW 3050/6010	SW 3010/6010
• Barium	SW 3050/6010	SW 3010/6010
• Boron	SW 3050/6010	SW 3010/6010
• Cadmium	SW 3050/6010	SW 3010/6010
• Chromium, total	SW 3050/6010	SW 3010/6010
• Lead	SW 3050/6010	SW 3010/6010
• Mercury	SW 7471	SW 7470
• Nickel	SW 3050/6010	SW 3010/6010
• Selenium	SW 3050/6010	SW 3010/6010
• Silver	SW 3050/6010	SW 3010/6010
• Calcium	-----	SW 3010/6010
• Magnesium	SW 3050/6010	SW 3010/6010
• Sodium	SW 3050/6010	SW 3010/6010
• Potassium	SW 3050/6010	SW 3010/6010
• Ammonia	EPA 350.2	EPA 350.3
• Total dissolved solids	-----	EPA 160.1
• Total suspended solids	-----	EPA 160.2
• pH	SW 9045	EPA 150.1
• Alkalinity, pht	-----	SM 403
• Alkalinity, MO	-----	SM 403
• Cyanide(total & amenable)	ASTM D2036	ASTM D2036
• Total Organic Carbon	Walkley-Black	EPA 415.1
• TCLP Leach	SW 1311	SW 1311
• Arsenic	-----	SW 3010/6010
• Barium	-----	SW 3010/6010
• Cadmium	-----	SW 3010/6010
• Chromium (total)	-----	SW 3010/6010
• Lead	-----	SW 3010/6010
• Mercury	-----	SW 7470
• Nickel	-----	SW 3010/6010
• Selenium	-----	SW 3010/6010
• Silver	-----	SW 3010/6010
• pH	-----	EPA 150.1
• ASTM Leach	ASTM D3987-85	-----
• Phosphate (ortho)	-----	EPA 365.2
• Sulfate	-----	EPA 375.4
• Nitrate	-----	EPA 353.2
• Chloride	-----	EPA 325.3

TABLE 1-2
ROCKY FLATS
WASTE CHARACTERIZATION ANALYTICAL METHOD LIST
PAGE TWO

ANALYSIS	METHOD	
	SLUDGE	LIQUID/EXTRACTS
Geotechnical Parameters		
• Moisture (Karl-Fisher)	ASTM E203	ASTM E203
• Moisture (Gravimetric)	ASTM D2216	-----
• Bulk Density	Agronomy No. 9 - Ch. 30	-----
• Specific Gravity	ASTM D854	-----
• Atterberg Limits	ASTM D4318	-----
• Swell Test	Free Swell Test (Holtz & Gibbs, 1956)	-----
Gross alpha	SW 3050/ EPA 900.0	EPA 900.0
Gross beta	SW 3050/ EPA 900.0	EPA 900.0

SW SW846 Test Methods for Evaluation of Solid Waste, Physical/Chemical methods, 3rd Edition.

EPA Methods for Chemical Analysis of Water and Wastes, EPA 600/4-79-020.

ASTM American Society of Testing Materials.

(1) Selected Volatiles
Acetone
Carbon disulfide
Carbon tetrachloride
Chlorobenzene
Ethyl acetone
Ethylbenzene
Ethyl ether
Methylene chloride
Methyl ethyl ketone
Methyl isobutyl ketone
Tetrachloroethene
Toluene
1,1,1-Trichloroethane
1,1,2-Trichloro-1,2,2-trifluoroethane
Trichloroethene
Trichlorofluoromethane
Xylene
1,1,2-Trichloroethane
Benzene

(2) Selected Semivolatiles
Cyclohexanone
1,2-Dichlorobenzene
Pyridene
2-Nitropropane

(3) Selected Alcohols
n-Butyl alcohol
Isobutanol
Methanol
2-Ethoxyethanol

TABLE 1-3

LIST OF REGULATED SOLVENTS FOR
F001, F002, F003, AND F005 WASTES

Hazardous Waste Number	Solvent
F001	Tetrachloroethylene Trichloroethylene Methylene Chloride 1,1,1-Trichloroethane Carbon Tetrachloride
F002	Chlorobenzene 1,1,2-Trichloro-1,2,2-Trifluoroethane Orthodichlorobenzene Trichlorofluoromethane 1,1,2-Trichlorethane Methylene Chloride
F003	Xylene Acetone Ethyl Acetate Ethylbenzene Ethyl Ether Methyl Isobutyl Ketone n-butyl Alcohol Cyclohexanone Methanol
F005	Toluene Methyl Ethyl Ketone Carbon Disulfide Isobutanol Pyridine Benzene 2-Ethoxyethanol 2-Nitropropane

The aqueous wastes were analyzed for alkalinity, total suspended solids, total dissolved solids, potassium, calcium, magnesium, and sodium. These parameters provided input to developing the waste/cement formulation. With the exception of total and dissolved solids, the sludge samples were also analyzed for the same parameters.

An ASTM leach test was conducted on the sludge. The leachate was analyzed for phosphate, sulfate, nitrate, chloride, and total dissolved solids. This analysis determined the amount, if any, of these compounds that redissolves. Additionally, these compounds can affect the cement chemistry.

Gross alpha and gross beta were analyzed on each waste form to characterize the activity level of the waste.

Several geotechnical parameters were analyzed to characterize the physical condition of the solid waste. Percent moisture, bulk density, and specific gravity are common physical parameters for characterization of the waste source. The Atterberg limits provided an indication of the plasticity of the material, providing information pertaining to the engineering behavior of the material. The swell test determines if dry material expands when exposed to water.

1.3.2 Waste Matrix Description

1.3.2.1 Pond 207C

The information in this section is condensed from the Pond Sludge and Clarifier Sludge Waste Characterization Report (Deliverable 224A and 224E, HALLIBURTON NUS, March 1992). Quadrant samples of water and sludge were collected in August 1991. Data summary tables can be found in the referenced report.

Water and sludge in Pond 207C contain high concentrations (approximately 10 percent) of nitrates and other salts that can in some circumstances adversely affect cement chemistry. Other constituents detected at high concentrations include potassium, sodium, and sulfate.

The pH of the pond contents ranged from approximately 10.0 to 10.5. The specific conductance of the water exceeded the capability of the monitoring instrument, greater than 50,000 umho/cm. The pond temperature at the time of sampling was 25°C (77°F). The pond water has a high salt content consistent with the high Total Dissolved Solids (TDS) levels which averaged 460,000 mg/l. The average specific gravity of the water was 1.332, suggesting a high dissolved salt content. The organic content, measured as Total Organic Carbon, averaged 1400 mg/l for the water and 7700 mg/kg for the sludge. The sludge and crystal samples contained an average solids content of 56%, based on the moisture analyses.

Two target volatile organics were detected in the 207C pond water. 2-Butanone (Methyl ethyl ketone) was detected in four of the five water samples. Methylene chloride was detected in only one of the water samples. Neither exceeded LDR standards. No target semi-volatile organics or alcohols were detected in any of the samples.

Total metals analysis of the water indicated that chromium, lead, and nickel are present at concentrations that exceed the their LDR (CCW) standards. Cyanide concentrations ranged from 3.3 to 20 mg/l, exceeding the LDR wastewater standard (CCW). Although the wastewater standard for cyanide is exceeded for the water phase, the total pond contents, once slurried, will be considered a non-wastewater because the total suspended solids will be greater than 1 percent. The non-wastewater standard is considerably higher than the wastewater standard for F006, F007, and F009 wastes (590 mg/kg vs. 1.2 mg/l) and will not be exceeded by the cyanide concentration of the contents of Pond 207C.

TCLP analysis of the water indicated that the leachate had arsenic and chromium present at levels that make the water a RCRA characteristic waste. The TCLP method for a liquid with less than 0.5 percent solids specifies analysis of the liquid following filtration, in essence making the TCLP leachate representative of the dissolved metals fraction.

The sludge samples analyzed during the characterization effort represent a mixture of the crystalline material and the fine-grained material that underlies the crystals, although not in any measured proportion. No target volatile compounds, semi-volatile compounds, or alcohols were detected at concentrations above specified regulatory limits. Arsenic, cadmium, chromium, nickel, and silver were detected in all five TCLP leachates. Barium was detected in three, lead in two, and mercury in one TCLP leachate. The TCLP leachate concentrations of cadmium and nickel exceeded their respective LDR standards, and cadmium leached at a concentration sufficient to classify the sludge as a RCRA waste based on the characteristic of toxicity.

The concentration of total cyanide in the sludge ranged from 13 to 170 mg/kg, which is still below the non-wastewater LDR standard of 590 mg/kg.

A summary of the parameters which are above the RCRA regulations is provided in Table 1-4. Based on the analytical results from the HALLIBURTON NUS Characterization Report, Pond 207C waste should also be RCRA hazardous waste based on the characteristic of toxicity (40 CFR 261.24) for arsenic and chromium, which correlates to D004 and D007, respectively.

1.3.2.2 Clarifier

The pH of the clarifier water was approximately 9.75 S.U. and the specific conductance of the liquid ranged from 30,000 to 40,000 umho/cm. The temperature at the time of sampling was 27.9°C (82.2°F).

No target volatile organics, semi-volatile organics, or alcohols were detected in the clarifier water. The clarifier water contained considerable amounts of inorganic contaminants. Arsenic, barium, boron, cadmium, chromium, mercury, nickel, and silver were detected in all four samples. Lead was detected in two of four samples. Chromium and lead were present at concentrations exceeding their respective LDR standards (CCW). In the TCLP leachate, only arsenic was detected in all four samples. Nickel was detected in three of the four leachates, at concentrations approximating those detected in the raw water analysis. Chromium was detected in two of the leachates.

Total cyanide was detected in the water at concentrations ranging from 2.4 to 3 mg/l. All the calculated amenable cyanide values were negative. Negative amenable cyanide results are typical if the cyanides are complexed with metals.

Cyanide concentrations were above the LDR wastewater regulatory limit of 1.2 mg/l. As was explained for Pond 207C, once the clarifier contents are slurried, the non-wastewater standard is applicable. The combined cyanide concentration of the sludge and water is below the non-wastewater standard of 590 mg/kg.

The sludge had a relatively high filterable solids content, averaging 39.4 percent solids. However, it should be noted that this includes an apparent high value of 66.9 percent solids for sample CS-001D. When this value is excluded, the average solids concentration drops to 30.2 percent. The average TOC of the sludge was 5250 mg/kg.

TABLE 1-4

207C SAMPLES EXCEEDING RCRA STANDARDS FOR THE
CHARACTERIZATION OF TOXICITY AND LAND DISPOSAL RESTRICTIONS
SOLAR POND/PONDCRETE PROJECT
ROCKY FLATS PLANT, COLORADO

Matrix	Constituent	Toxicity Characteristic Standard(1) (ug/l)	TCLP Extract Concentration(2) (ug/l)	LDR Standard F006, F007 and F009 (ug/l)	TCLP Extract (ug/L)	Concentration in Waste
207C Water	Arsenic	5000	5510	NA	NA	NA
	Cyanide-Total	MA	NA	1200 CCW	NA	3300 20000 4000 7100 4100
	Chromium	NA	NA	320 CCW	NA	3580 3400 3370 3320 3940
	Lead	NA	NA	40 CCW	NA	300 300
	Nickel	NA	NA	440 CCW	NA	2610 2920 2560 2540 2790
207C Sludge	Cadmium	NA	NA	66 CCWE	945 5230 475 342 444	NA
	Nickel	NA	NA	320 CCWE	40 2140 563 624 765	NA

NA - Not Applicable
TCLP - Toxicity Characteristic Leaching Procedure.
(1) Waste is a RCRA hazardous waste based on the characteristic of toxicity if the TC standard is exceeded.
(2) The TCLP method specifies that for liquids with less than 0.5% solids, the liquid should be filtered through a 0.6-0.8 um glass fiber filter to remove the solids, and then analyzed without extraction.

Four target volatile organics were detected in the sludge; 1,1,1-trichloroethane, 1,1,2-trichloro-1,2,2-trifluoroethane, 2-butanone, and tetrachloroethene (PCE). None of these contaminants are at a concentration which is of a regulatory concern.

All of the target inorganics were detected in all four of the samples, with the exception of arsenic, which was detected in only two of the samples, and selenium, which was not detected. The highest values in any of the sludges were found in samples from the clarifier for the following constituents: cadmium (4660 mg/kg), chromium (3190 mg/kg), lead (191 mg/kg), mercury (14 mg/kg), nickel (902 mg/kg), and silver (166 mg/kg).

Four metals, arsenic, cadmium, chromium, and nickel, were detected in the TCLP leachate in all four samples. Cadmium and nickel exceeded their respective LDR standards, while cadmium also exceeded the TCLP standard for classifying the sludge as a hazardous waste based on the characteristic of toxicity. Silver, barium, lead, and mercury were also detected in some of the TCLP leachate samples.

Total cyanide was detected in all four samples at concentrations ranging from 21 to 190 mg/kg. These concentrations are still below the LDR standard of 590 mg/kg.

The parameters which were detected at concentrations above the LDR and toxicity criteria requirements are summarized in Table 1-5.

1.3.3 Waste Composite Data

Bulk composite samples of water and sludge were collected from Pond 207C and the clarifier in December 1991 to provide sufficient volume for the treatability study. An aliquot of each bulk sample was submitted to the laboratory for analysis to serve as a baseline analysis of the waste used for treatability study testing, and as a check of the individual quadrant analyses reported as part of the waste characterization effort. The water analytical data for Pond 207C and the clarifier are reported in Table 1-6, while the sludge data are reported in Table 1-7.

The composite 207C water sample was less concentrated than the average gradient samples collected during waste characterization, as evidenced by lower concentrations for individual inorganics (sodium and potassium), TDS, and

TABLE 1-5
CLARIFIER CHARACTERIZATION SAMPLES EXCEEDING TCLP STANDARDS FOR THE CHARACTERIZATION OF TOXICITY
SOLAR POND/PONDCRETE PROJECT
ROCKY FLATS PLANT, COLORADO

Matrix	Constituent	Toxicity Characteristic Standard[1] (ug/l)	TCLP Extract Concentration[2] (ug/l)	LDR Standard for F006, F007, and F009 (ug/l)	TCLP Extract (ug/L)	Concentration In Waste (ug/L)
Clarifier Water	Chromium	NA	NA	320 CCW	NA	825
	Lead	NA	NA	40 CCW	NA	46
	Cyanide-Total	NA	NA	1200 CCW	NA	2400 2700 2800 3000
Clarifier Sludge	Cadmium	1000	14800 17400 25900 24500	66 CCWE	14800 17400 25900 24500	NA
	Nickel	NA	NA	320 CCWE	7010 6990 8300 7300	NA

NA - Not Applicable
TCLP - Toxicity Characteristic Leaching Procedure.

(1) Waste is a RCRA hazardous waste based on the characteristic of toxicity if the TC standard is exceeded.

(2) The TCLP method specifies that for liquids with less than 0.5% solids, the liquid should be filtered through a 0.6-0.8 um glass fiber filter to remove the solids, and then analyzed without extraction.

TABLE 1-6

POND 207C AND CLARIFIER WATER COMPOSITE CHARACTERIZATION DATA
SOLAR POND/PONDCRETE PROJECT
ROCKY FLATS PLANT, COLORADO

Analysis	Units	207C Water Composite PW-207C-C	Clarifier Water Composite CW-004-C
VOLATILES(1)			
Acetone	ug/l	53J	16J
2-Butanone	ug/l	31J	ND
SEMIVOLATILES(1)	ug/l	ND	ND
ALCOHOLS(1)	mg/l	ND	ND
INORGANICS			
Arsenic	ug/l	3680	940
Barium	ug/l	100	30.0
Boron	ug/l	377,000	27,400
Cadmium	ug/l	520	80
Calcium	ug/l	11,000	18,700
Chromium	ug/l	2430	220
Lead	ug/l	ND	ND
Magnesium	ug/l	3130	3740
Mercury	ug/l	ND	1.0
Nickel	ug/l	2210	ND
Potassium	ug/l	32,700,000	4,690,000
Selenium	ug/l	ND	ND
Silver	ug/l	360	60.0
Sodium	ug/l	95,500,000	18,600,000
TCLP LEACH			
Arsenic	ug/l	463	521
Barium	ug/l	17.0	204
Cadmium	ug/l	38.0	19.0
Chromium	ug/l	139	99.0
Lead	ug/l	22.0	ND
Mercury	ug/l	0.2	0.7
Nickel	ug/l	233	242
Selenium	ug/l	ND	ND
Silver	ug/l	21.0	42.0
pH	Units	10.2	10.1
MISCELLANEOUS			
Alkalinity (Methyl Orange)	mg/l	36,000	6200
Alkalinity (Phenolphthalein)	mg/l	16,000	2300
Ammonia	mg/l	0.9	12
Chloride	mg/l	20,000	1600
Cyanide-Amenable	mg/l	-34	-31
Cyanide-Total	mg/l	3.3	3.0
Gross Alpha	pCi/l	110+/-20	17+/-2
Gross Beta	pCi/l	120+/-20	23+/-3
Nitrate	mg/l	39,000	5000
pH	Units	10.0	10.0
Phosphorus, Total (as P)	mg/l	88	24
Specific Gravity	--	1.244	1.034
Sulfate (as SO_4)	mg/l	13,000	3400
TDS (Total Dissolved Solids)	mg/l	360,000	49,000
TOC (Total Organic Carbon)	mg/l	2400	390
TSS (Total Suspended Solids)	mg/l	790	270

TABLE 1-6
POND 207C AND CLARIFIER WATER COMPOSITE CHARACTERIZATION DATA
SOLAR POND/PONDCRETE PROJECT
ROCKY FLATS PLANT, COLORADO
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J Estimated Value
ND Not Detected
pCi/l Picocuries per Liter

(1) Only compounds with positive detections are listed. The complete list of compounds analyzed is shown in Table 1-2.

TABLE 1-7

POND 207C AND CLARIFIER SLUDGE COMPOSITE CHARACTERIZATION DATA
SOLAR POND/PONDCRETE PROJECT
ROCKY FLATS PLANT, COLORADO

Analysis	Units	207C Crystal Composite PS-207C-C-C	207C Silt Composite PS-207C-C-S	Clarifier Sludge Composite CS-004-C
VOLATILES(1)				
1,1,2-Trichloro-1,2,2-trifluoroethane	ug/kg	ND	ND	79
2-Butanone	ug/kg	ND	54	84
Xylenes (Total)	ug/kg	ND	21	17J
Acetone	ug/kg	60	140	260J
1,1,1-Trichloroethane	ug/kg	ND	ND	14J
Toluene	ug/kg	ND	10	ND
Chlorobenzene	ug/kg	ND	8	ND
Tetrachloroethene (PCE)	ug/kg	ND	ND	420
SEMIVOLATILES(1)	ug/kg	ND	ND	ND
ALCOHOLS(1)	mg/kg	ND	ND	ND
MISCELLANEOUS				
Ammonia	mg/kg	ND	ND	71
Atterberg - Liquid Limit	--	NA	NA	NA
Atterberg - Plastic Index	--	NA	NA	NA
Atterberg - Plastic Limit	--	NA	NA	NA
Bulk Density (Dried Solids)	g/cc	NA	NA	NA
Cyanide-Amenable	mg/kg	NA	NA	NA
Cyanide-Total	mg/kg	4.7	21	21
Gross Alpha	pCi/g	39+/-6	3.3+/-0.4	3100+/-400
Gross Beta	pCi/g	59+/-6	530+/-60	390+/40
Moisture-Gravimetric	%	58.2	40.8	71.9
Water-Karl Fisher	%	NA	NA	NA
pH	Units	11.0	10.4	9.8
Specific Gravity	--	1.43	1.46	1.25
Swell Test	%	INT	0	30
TOC (Total Organic Carbon)	mg/kg	980	4900	3600
Chloride(2)	mg/l	420	660	110
Nitrate(2)	mg/l	1200	2400	510
% Recovery of Solids(2)	%	NA	NA	NA
Phosphorus, Total (as P)(2)	mg/l	14	31	39
Sulfate(2)	mg/l	480	1000	280
TDS (Total Dissolved Solids)(2)	mg/l	19,000	25,000	4400
INORGANICS				
Arsenic	mg/kg	40.2J	15.7J	ND
Barium	mg/kg	0.72J	18.7J	159J
Boron	mg/kg	577	615	990
Cadmium	mg/kg	ND	27.0J	2860J
Chromium	mg/kg	2.9J	482J	2350J
Lead	mg/kg	ND	12.2J	142
Aluminum	mg/kg	ND	1520J	30500
Calcium	mg/kg	ND	12800J	39600
Iron	mg/kg	13.2	1040J	5380
Magnesium	mg/kg	9.6J	2250J	17700J
Mercury	mg/kg	0.1	4.4	9.0
Nickel	mg/kg	ND	33.8J	700J
Potassium	mg/kg	35,800	52100J	62300J
Selenium	mg/kg	ND	ND	ND
Silver	mg/kg	ND	44.1J	138J
Sodium	mg/kg	388,000	194,000J	85400J

TABLE 1-7
POND 207C AND CLARIFIER SLUDGE COMPOSITE CHARACTERIZATION DATA
SOLAR POND/PONDCRETE PROJECT
ROCKY FLATS PLANT, COLORADO
PAGE TWO

Analysis	Units	207C Crystal Composite PS-207C-C-C	207C Silt Composite PS-207C-C-S	Clarifier Sludge Composite CS-004-C
TCLP LEACH				
Arsenic	ug/l	593	447	233
Barium	ug/l	490	536	357
Cadmium	ug/l	26.0	670	64,600
Chromium	ug/l	90.0	7280	2360
Lead	ug/l	25.0	ND	21.0
Mercury	ug/l	0.2	5.4	57
Nickel	ug/l	129	762	13300
Selenium	ug/l	ND	ND	ND
Silver	ug/l	ND	67.0	ND
pH	Units	5.3	4.4	4.1

ND Not Detected
NA Not Analyzed
pCi/g Picocuries per Gram
NP Not possible to analyze due to nature of solids.

(1) Only compounds with positive detections are listed. The complete list of compounds analyzed is shown in Table 1-2.
(2) Following ASTM Leach.

specific gravity. The TCLP metals concentrations were also an order of magnitude lower, which is indicative of the dissolved metals concentration for low turbidity water.

Bulk composite samples of Pond 207C silt and crystal were analyzed separately. The silt composite sample more closely resembles the characterization data for 207C sludge reported in Deliverable 224A/224E. No significant differences in individual analyte concentrations were noted.

The composite clarifier water sample data reasonably matched the characterization data previously reported. The composite clarifier sludge sample exhibited several differences from the characterization data reported in Deliverable 224A/224E. The TCLP concentrations of chromium (2360 ug/l vs. 362 ug/l) and mercury (57mg/l vs. 1.5 ug/l) were higher in the composite than the average of characterization data reported earlier. All other composite clarifier sludge data was similar to characterization data.

1.4 REMEDIAL TECHNOLOGY DESCRIPTION

1.4.1 Literature Review of Similar Stabilization Projects

The evaluation of the characterization results for Pond 207C indicate a matrix consisting of high salt, low radioactivity material in an alkaline environment. Upon review of historical literature, a few stabilization projects of similar nature have been documented in the past. The majority of these stabilization projects were accomplished using a blend of cement and fly ash.

Review of three articles addressing the solidification and stabilization of low-level radioactive, high salt waste (McVay, May 1983; Hodges, March 1989; Sams, undated) indicates that all utilize a similar grout mixture. The grout mixtures used all consisted of cement plus the addition of a pozzolanic material. The most common pozzolans used were fly ash or fly ash plus blast furnace slag in the case of the Melton Valley project. All of the projects produced a stable solidified waste form with these grout mixtures.

The most closely related project is the solidification of a low-level alkaline salt solution that was accomplished at the Savannah River Plant (SRP) (Wilhite, undated). This solution was solidified and placed in surface vaults. The solidification of this material was completed with Type H cement and Type C fly ash at a 0.25 ratio. Initially the waste contained mostly nitrate salts and 160 ppm of chromium. Extraction Procedure-Toxicity Testing was performed on the solidified product and the leachate was found to be at acceptable levels for chromium and other metals.

1.4.2 Process Overview

The proposed remediation process for Pond 207C and the clarifier is chemical stabilization/solidification with a pozzolanic mixture. The pozzolanic mixture consists of Type V cement, Type C flyash, and hydrated lime.

The full scale remediation will consist of pumping a homogenized slurry from Pond 207C to a scalping screen which will remove large material or debris. The oversized material is discharged from the scalping screen to a holding bin for processing at the 904 pad at a later date. From the scalping screen, the 207C slurry will be pumped to a series of averaging tanks and a contact chlorination tank where calcium hypochlorite will be added for disinfection. The slurry then is transferred to a series of batch tanks prior to mixing with the pozzolans. The mixing with cement, flyash, and lime will occur in a Halliburton Services Recirculating Cement Mixer (RCM). The cement, flyash, and lime will be preblended at the prescribed ratio. The blended pozzolans will be stored in a bulk storage silo. The final stabilized product will be cast into half crates for final storage.

Remediation of the clarifier contents will include first reclaiming the clarifier sludge and water then mixing the material in a holding tank. Next, the slurry will be pumped to the 207C process train to be blended with the 207C slurry. The 207C process train will be operated as above.

1.4.3 Treatability Study Overview

The CSS formulation development was conducted on a bench-scale level. The process primarily consisted of blending homogenized waste stream samples with varying quantities of pozzolans and then conducting the necessary analysis to determine if the specified formula passed the required criteria.

Testing was conducted using 207C water with varying concentrations of the silty sludge, and 207C water and silty sludge mixed with clarifier sludge. All of the above combinations used 207C water that was saturated with dissolved salts. The solutions were known to have been saturated because of the observations of precipitated salts.

The formulation development was conducted using factorial experiments. Factorial experiments allow independent evaluation of the effect on one variable from the interaction of other variables. Factorial experiments are designed to evaluate each potential combination for all parameters or variables. In factorial experiments all of the parameters can be varied simultaneously which allows assessment of the interaction of the variables. Measured responses of the factorial experiment can be evaluated as a function of the variable to determine optimum responses and key variable interactions.

In the early stages of formula development the factorial experiment was designed to evaluate the cement to flyash ratio. In the later stages of the process development, after a cement to flyash ratio was determined, the pozzolan to water ratio was varied along with the solids loadings. The pozzolan to water ratio was varied from 0.34 to 0.56 which is expected to be an adequate operation range for remediation.

Various tests were required to determine if a specific formula was successful. The solidified material was required to pass all RCRA Land Disposal Restriction requirements (40 CFR 268) and requirements for wastes that are characteristic hazardous wastes for toxicity (40 CFR 261). The solidified product was analyzed for TC metals (40 CFR 261) and nickel (F006, F007, and F009 Standard) and zero head space TCLP for volatile organics. The solidified material also had to pass several criteria for transportation of the solidified waste and NTS acceptance such as the Standard Test Method for Determining whether a Material is a Liquid or a Solid and the Paint Filter Liquids Test (ASTM D4359-84 and SW 9095, respectively). Passing these tests is required for acceptance at Nevada Test Site.

Durability testing was also conducted to determine the ability of various formulas to withstand changing environmental conditions. These tests included the Standard Test Methods for Wetting and Drying Compacted Soil-Cement Mixtures (wet/dry) and the Standard Test Method for Freezing and Thawing Compacted Soil-Cement (freeze/thaw). These tests followed ASTM Methods D559-82 and D560, respectively . Although successfully passing these tests does not correlate to a time frame for the stability of the final product, the data are useful for comparing the quality of various CSS formulas. Unconfined compressive strength (UCS) tests (ASTM C39-86) were used as a screening mechanism between various formulas and to measure strength vs time for each formula.

The latter three tests; wet/dry, freeze/thaw, and UCS, are not required for product certification. These tests were used as indicators to determine if a specified formula was of better quality than another formula with regard to strength and durability.

2.0 TREATABILITY STUDY APPROACH

This section describes the requirements and procedures for conducting the treatability study used to develop the chemical stabilization and solidification (CSS) formulations for Pond 207C and the clarifier.

The purpose of this treatability study was to develop CSS formulations to stabilize and solidify the subject wastes. Candidate formulations were selected to produce a final waste form that achieves all requirements currently in effect. These include requirements of U.S. Environmental Protection Agency (EPA) Region VIII, the Colorado Department of Health, U.S. Department of Transportation (DOT), and the Nevada Test Site (NTS), which is the facility that EG&G has indicated will ultimately receive the treated wastes.

The final waste form must be certifiable and acceptable for transportation and land disposal. The following criteria must be met in order for the waste form to be certifiable:

- Chemically and physically stable as defined by NVO-325, October 1988.

- A solid (no free liquids) as defined by NVO-325, October 1988, Section 2.2.2-D; DOT regulations in 49 CFR 173; EPA Test Method 9095 (EPA-246); and ASTM Method D4359-84.

- Does not contain pathogens, infectious wastes, or other etiologic agents as defined in 49 CFR 173.386.

- The solidified waste must be treated to comply with all Land Disposal Restrictions as stated in 40 CFR 268.

- Transportable in interstate commerce as defined by DOT regulations in 49 CFR 173 and EPA regulations in 40 CFR 263.

- Within radioactive limits as defined by NVO-325, October 1988, Section 2.1.1-D and DOT Regulations in 49 CFR 173, Subpart I (173.400).

- Certifiable as a waste as defined by (1) the Rocky Flats Quality Assurance Manual, Low Level Waste Management Plan, 1-10000 EWQM, Section 1.1, RFP Procedures and (2) NVO-325, October 1988.

2.1 GOALS AND OBJECTIVES

The goal of the treatability study was to develop a CSS formula that is successful in producing a final waste product that can be certified for disposal as per the requirements stated above in Section 2.0. During the treatability study, it was necessary to determine the optimum ratios for waste to binder(s) and admixture(s) to achieve acceptable physical characteristics and chemical leachability criteria. Upon achieving successful CSS formulas for physical characteristic and chemical leachability criteria, then long-term durability characteristics of the final treated waste form were evaluated.

The general concept used for developing process formulations for the waste form followed a progression from screening binder/waste formulations through a more comprehensive evaluation of variables and additives. The candidate formulations that passed all of the previous evaluation criteria were then subjected to regulatory compliance testing. The chronology of CSS formulation development is summarized in Table 2-1 and the logic is provided in Figure 2-1.

The Phase I/II screening tests used an accelerated curing procedure where various ratios of waste, binder, additives, and water were prepared and cured at elevated temperatures for 48 hours. Formulations that did not develop sufficient strength or contained free water after curing were eliminated from further consideration.

The accelerated curing procedure provided an indication of the potential strength of the solidified waste. It was used as an indicator of the probability that the desired compressive strength could be obtained by use of a particular CSS formulation under normal long-term curing. This procedure saved time by not curing the test specimens for the conventional 28-day period, which allowed more testing to be conducted in a short time period.

The accelerated curing followed a modified version of ASTM Method C684-81 (Procedure A - Warm Water Method). The ASTM method was modified to allow for a 48-hour cure rather than the 24-hour cure specified in the method.

Phase III/IV testing was performed on specimens that were cured using the conventional 28-day procedure to determine compliance with regulatory and

TABLE 2-1

POND 207C/CLARIFIER CSS TREATABILITY STUDY SUMMARY

ROCKY FLATS PLANT, COLORADO

Phase	Waste Material	Date Mixes Prepared	Curing	Testing	Objective	Results
Preliminary Testing	207C Water and Sludge	Nov. 1991	Normal (24 Days)	UCS TCLP-Metals Freeze/Thaw Wet/Dry	Preliminary evaluation of cement/flyash and cement/flyash/Latex 2000 systems for stabilization of high-salt waste.	Achieved acceptable UCS results. Passed TCLP-metal criteria for LDR standards and RCRA toxicity standards. Did not pass wet/dry or freeze/thaw durability testing.
I/II Screening	207C Water and Sludge	Jan. 1992	Accelerated (48 Hr.)	UCS TCLP-Metals Freeze/Thaw (Concentrated) Wet/Dry (Concentrated)	Factorial testing of lime/cement/flyash system plus five additives (Latex 2000, plastic fibers, sodium silicate, HR-4 and HR-25) to improve durability performance. Switched to Type V cement from Type I and II cement for resistance to sulfate attack.	Formulations with lime/cement/flyash + 3 of the additives (Latex 2000, sodium silicate and plastic fibers had acceptable UCS results. HR-4 and HR-25 retarded cement set and were eliminated from further consideration. All testing for TCLP metals were below LDR and RCRA toxicity treatment standards. Testing for accelerated wet/dry and freeze/thaw was passed for the lime/cement/flyash formula and the mines with the three additives. However, the sodium silicate and plastic fibers were eliminated because they showed no benefit. Lime/cement/flyash and lime/cement/flyash + Latex 2000 was retained for further testing.
I/II Screening	Clarifier	Jan. 1992	Accelerated (48 Hr.)	TCLP-Metals Freeze/Thaw (Accelerated) Wet/Dry (Accelerated)	Factorial testing of lime/cement/flyash system plus three additives (Latex 2000, plastic fibers, and sodium silicate) to improve durability performance.	Formulations achieved acceptable UCS. TCLP metals were below LDR and RCRA toxicity treatment standards. None of the formulations passed the wet/dry or freeze/dry durability testing.
III/IV Regulatory Confirmation	207C Water and Sludge	Feb. 1992	Normal (28 Days)	UCS TCLP-Metals, Volatiles (Selected Single) Freeze/Thaw Wet/Dry Paint Filter Liquids Test Liquid/Solids Test	Lime/cement/flyash and lime/cement/flyash/Latex 2000 systems selected for regulatory phase testing. Emphasis if testing was to develop operating range for cement/flyash and for water/pozzolan ratios.	Achieved acceptable UCS results. Passed all regulatory requirements. Passed wet/dry and freeze/thaw testing, except one of the Latex formulas failed the wet/dry test in Cycle 10.
III/IV Regulatory Confirmation	207C Water and Sludge + Clarifier 207C Water and Sludge	April 1992	Normal (28 Days)	UCS TCLP-Metals, Volatiles (Selected Single) Freeze/Thaw Wet/Dry Paint Filter Liquids Test Liquid/Solids Test	Lime/cement/flyash and lime/cement/flyash/Latex 2000 systems selected for regulatory phase testing. Emphasis of testing was to develop range for water/pozzolan ratio and to test different solids loadings. This phase was the only phase in which combined 207C/Clarifier waste was tested. Low-solids 207C water also tested to simulate pond wash-down conditions.	Achieved acceptable UCS results. Passed all paint filter liquids and liquid/solids testing. All testing passed LDR and RCRA toxicity criteria. Several batches at worst-case conditions (0.5 water to pozzolan ratio, 17% TSS, 49% TS) failed during durability testing.

disposal site requirements, and to estimate long-term durability. Only the most promising CSS formulas from Phase I/II screening were carried into Phase III/IV.

2.2 TREATABILITY STUDY TESTING SUMMARY

Results of the preliminary testing and Phase I/II testing were previously presented in technical memoranda, which are appended to this report (See Attachment A). The results of this testing are briefly described in the following sections, with an emphasis on the conclusions and the implications for subsequent rounds of testing.

2.2.1 207C Treatability Testing

2.2.1.1 Preliminary Testing

Preliminary testing was conducted in November of 1991 to obtain initial data for stabilization of Pond 207C waste. At this time, only limited sample was available for the treatability studies. Therefore, a full set of factorial experiments could not be performed. Because 207C was considered the most challenging pond waste to stabilize, a limited set of mixes was prepared in order to generate data before the bulk sample for treatability testing was collected. The main objective of the preliminary testing was to determine if a cement/flyash system was capable of stabilizing the high-salt brine in Pond 207C. This testing consisted of mixing two batches of 207C material. The first batch used 207C water and sludge mixed with lime, Type C flyash, and Type I-II cement. The second batch used the above materials plus the Halliburton Latex 2000 System.

The purpose of evaluating the Latex 2000 System was to determine if it would encapsulate the salt, thereby preventing efflorescence which is the formation of an external precipitate. Additionally, the latex has been shown to lower the permeability of the solidified material, which would reduce moisture penetration and possibly minimize crystal growth.

In both batches the cement to flyash ratio was 1 to 2. The water to pozzolan (cement plus flyash) ratio was approximately 0.46 for each batch.

Testing included unconfined compressive strength (UCS), TCLP metals analysis, and freeze/thaw, wet/dry durability testing. After 24 days of normal curing the UCS results were greater than 600 psi for both batches. The TCLP results were below the LDR requirements (40 CFR 268) and the RCRA toxicity characteristic requirements (40 CFR 261).

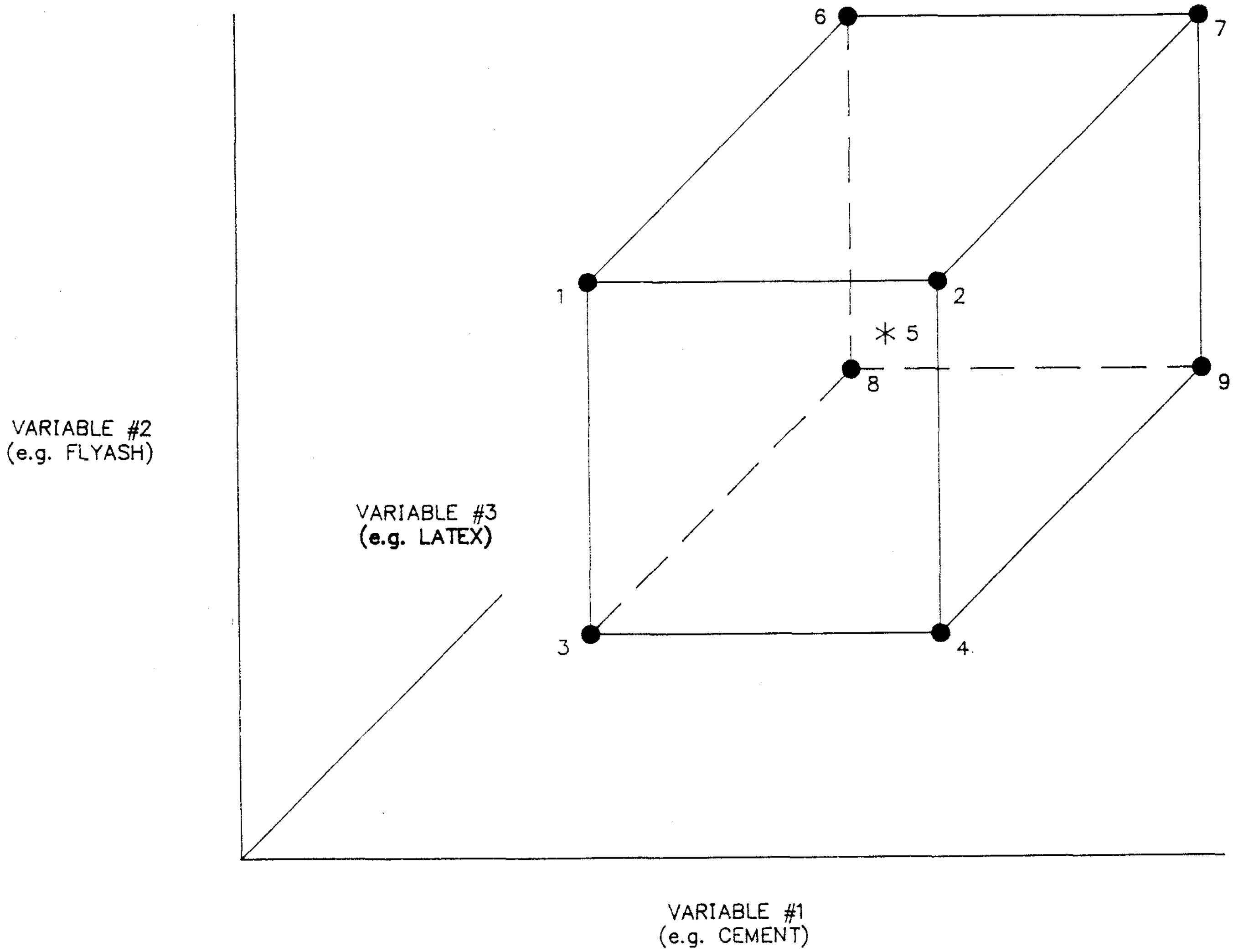
Neither batch successfully passed all of the durability testing. The lime/cement/flyash batch failed the wet/dry test in cycle 8 and failed the freeze/thaw test in cycle 9. The batch with the Latex 2000 System passed the wet/dry test but failed the freeze/thaw test in cycle 3. Additional details of this testing are provided in the Memo from T. Snare to T. Bittner dated January 20, 1992 (see Attachment A-1).

The results of the preliminary testing indicated that a cement/flyash system was capable of stabilizing Pond 207C waste based on strength (UCS) and regulatory parameters (TC and LDR constituents). Additional testing was required to improve durability performance.

2.2.1.2 Phase I/II Testing

The Phase I/II testing conducted in January 1992 was the initial large-scale mixing of CSS formulations. The objective was to screen various formulations based on a lime/cement/flyash system. Testing in this phase was conducted using factorial-type experimental design. Factorial experiments allow evaluation of the interaction of several variables to determine if one of the variables has a greater impact on the CSS formula development. The variables which were evaluated during this phase of the testing were the interaction of the cement, flyash, and additive dosages. The factorial experiments were designed to vary the dosages of each of the above parameters by a fixed percentage. Figure 2-2 represents a 3x3 factorial experiment in which cement, flyash, and additive (Latex 2000) dosages were varied around a center point concentration.

Testing conducted in Phase I/II was based on the results of testing conducted in the preliminary phase. The quantity of pozzolans used for the center point of the factorial experiments was the dosage used in the preliminary test increased by 25 percent. The pozzolan dosage was increased to try to improve performance in the wet/dry and freeze/thaw durability tests. This testing involved experiments using binder formulations of Type V portland cement, Type C flyash, and hydrated lime. The preliminary testing successfully demonstrated that the CSS formula could achieve acceptable strength and pass the LDR requirements. The purpose of this testing was to improve long-term durability of the stabilized waste.



LEGEND

⁎ CENTER POINT CONCENTRATION

● CONCENTRATIONS ± %
AROUND CENTER POINT

FIGURE 2-2

EXAMPLE OF THREE VARIABLES EVALUATED AT THREE CONCENTRATIONS ROCKY FLATS, GOLDEN, COLORADO

NOT TO SCALE

HALLIBURTON NUS *Environmental Corporation*

The cement used in the preliminary testing was Portland Type I-II, which is used for situations where moderate sulfate attack is possible. However, upon evaluation of the sulfate concentrations in Pond 207C, a decision to use Type V cement was made. The mean sulfate concentration of the 207C water is 17,000 mg/l sulfate which is in the range where Type V cement (sulfate-resistant cement) plus a pozzolan which improves sulfate resistance is recommended (Portland Cement Association, 1979). Section 2.3.2.3 contains further discussion of the decision to use Type V cement for all further testing of 207C and clarifier waste.

During this phase of the treatability study for Pond 207C, an evaluation of admixtures was conducted. The admixtures evaluated included plastic fibers, sodium silicate, Latex 2000 system (proprietary Halliburton Services additive reduces permeability), and HR-25 and HR-4 (proprietary Halliburton Services cement retarders). These additives were evaluated to determine their effect on durability testing performance.

The plastic fibers were added to the CSS formulation because they can act as reinforcing and should prevent the solidified material from falling apart if cracks develop. Sodium silicate can provide several improvements to CSS formulations, including the reaction of soluble silicates with metal ions to form low solubility metal silicates. The second reaction occurs between soluble silicates and reactive components of portland cement. This reaction results in a gel structure which has better solid properties, especially for waste with low solids content (Conner, 1990).

The Latex 2000 System was evaluated to determine if it would reduce crystal growth in the final waste product. Because the latex system reduces permeability, it was thought that crystal growth might be reduced by preventing excess water from contacting the salts, and thereby preventing growth of crystals.

HR-25 and HR-4 are proprietary cement retarder additives supplied by Halliburton Services. Both were used in this application because testing conducted at the Halliburton Research Center at Duncan, Oklahoma, indicated that these additives reduced efflorescence in surrogate material. Although no efflorescence was observed in the actual waste, these additives were evaluated because it was thought that they might improve long-term disability.

After the specimens for each formulation were cured for 48 hours (accelerated method), they were evaluated for free liquids and then strength by UCS testing if no free water was present. The only cylinders which had free water present were those cylinders which had the HR-4 or HR-25 additives. The reason for the presence of free water is because the additive dosage was apparently too high, which resulted in retardation of the cement chemistry. All of the remaining cylinders developed a minimum of 100 psi after the 48-hour accelerated cures, and the more successful formulas achieved strengths of approximately 600 psi. In general, cylinders which achieved UCS results greater than 200 psi appeared to be good cylinders visually and continued no free liquids. Although the Paint Filter Liquids test and the Liquid/Solids test were not conducted, cylinders with UCS results of 200 psi after 48-hour cures should easily pass these tests. Formulations that passed the strength criteria were leached using the TCLP method, and the extract was analyzed for metals. Formulations that passed the strength criteria were also evaluated for accelerated wet/dry and freeze/thaw durability. The durability test specimens were evaluated for strength after the completion of the wet/dry and freeze/thaw durability tests to determine whether a decrease in strength occurred.

The freeze/thaw and wet/dry durability test procedures (ASTM D560 and D559) were modified for Phase I/II to enable the testing to be completed in an expedient manner because of schedule constraints. The control cylinder (i.e., volume and moisture control specimen) was omitted, thus only one cylinder was submitted for each test. The dimension measurements and the weighing of the cylinders after each cycle were omitted. Brushing of the cylinders was done as specified in the methods. The freeze/thaw procedure was accelerated by reducing the time of freezing from 24 hours/cycle to 12 hours/cycle. *The wet/dry procedure* was accelerated by decreasing the drying period from 42 hours to 19 hours and the time of submergence from 5 hours to 4 hours. This enabled the cycle to be performed in a 23-hour cycle giving the lab one hour leeway to move the samples as required.

The results of these tests are provided in the Technical Memorandum for 207C Stabilization, Revision 1 dated May 1992 (see Attachment A-2). In summary, the results indicated that all but one of the cylinders prepared with lime/cement/ flyash, lime/cement/flyash/plastic fibers, lime/cement/flyash/sodium silicate, and lime/cement/flyash/Latex 2000 passed all of the LDR criteria and the accelerated durability testing. The exception was that one of the nine tests using lime/cement/flyash/sodium silicate failed the wet/dry durability test.

The mixes prepared with HR-4 and HR-25 were not successful. The dosages used for these admixtures were too high, as observed by the inability of the cylinders to achieve acceptable UCS results after accelerated 48-hour cures. Many of the cylinders did not set during the cure time and had free water present. Evaluation of the TCLP results were not conducted. These results were invalid because of laboratory error during performance of the TCLP extraction procedure. A larger quantity of acetic acid than required by the method was added to the leach solution. Because excess acid was used in the extraction procedure, the pH was reduced significantly, resulting in the metals of concern becoming more soluble and thus invalidating the results (additional details are provided in Attachment A-2).

In general, it was concluded that none of the additives provided any increased ability to withstand the durability tests, with the possible exception of latex. Because there appeared to be no obvious benefit from the use of plastic fibers, sodium silicate, HR-25, and HR-4, they were eliminated from further testing. The results for the lime/cement/flyash batches had the best results with regard to UCS, TCLP, and durability tests. However, the Latex 2000 system may have had some benefit regarding microscopic encapsulation of salt crystals in the stabilized matrix.

The cylinders with the Latex 2000 System and the lime/cement/flyash cylinders were analyzed using petrographic methods. Some of the cylinders with latex appeared to have a good tight cement matrix with no visible cracks or pores. The cylinders with latex had a better quality hydration in the low cement ratio blends compared to the corresponding blends without the latex added (HALLIBURTON Services Research Center, April 1992). For these reasons, the Latex 2000 System was carried into the Final Confirmation Phase.

2.2.2 CLARIFIER TREATABILITY TESTING

2.2.2.1 Phase I/II Testing

The Phase I/II clarifier tests were conducted in a fashion similar to that of 207C. The clarifier testing evaluated the addition of plastic fibers and sodium silicate to a lime/cement/flyash CSS formula. Because of the poor results obtained on 207C waste using the additives HR-4 and HR-25, these additives were dropped from further consideration. The procedures and results of this testing are provided in Attachment A-3. The results are briefly summarized below:

- The additives tested (plastic fibers and sodium silicate) did not appear to provide significant improvement for durability or strength when compared to the lime/cement/flyash mixture.

- All of the mixtures with Type V cement and Type C flyash at a ratio of 1 to 2 achieved UCS results of at least 100 psi and had no free water present after curing. The water to pozzolan (cement plus flyash) ratios that were tested are as follows:

  Batch 1 = 0.69
  Batch 2 = 0.61
  Batch 3 = 0.99
  Batch 4 = 0.82
  Batch 5 = 0.76

- The formulations prepared were not adequate for the freeze/thaw and wet/dry durability testing. Very few cylinders successfully passed the freeze/thaw test and none passed the wet/dry test. Failure for the wet/dry testing is likely related to the high water to pozzolan ratio, and possibly related to the presence of sulfate in the clarifier sludge. The sulfate may react with components of the Type C flyash during the drying cycle of the wet/dry test, resulting in an unstable product and subsequent failure of the test.

- The results of the TCLP analysis for the lime/cement/flyash formulation using 0.8% to 1.0% lime by weight of the total end product successfully met all Land Disposal Restriction criteria.

2.2.2.2 Phase III/IV Testing

No Phase III/IV confirmatory testing was conducted solely on clarifier waste because of the decision to combine clarifier waste with 207C waste for processing. See Section 2.2.3 for a discussion of the Phase III/IV testing of the combined 207C/clarifier waste.

2.2.3 <u>Confirmation Phase for Pond 207C and Pond 207C Combined With the Clarifier</u>

A decision to process both 207C and the clarifier contents in the same process train was made during the performance of the treatability study, resulting in the need to conduct treatability testing on the combined waste streams.

Additionally, testing was required on 207C material by itself because the clarifier contents will be treated in a short time period, which will necessitate initially treating 207C without the addition of the clarifier waste stream.

The final phase of testing was conducted using hydrated lime, Type V portland cement, and Type C flyash at a ratio of one part cement to two parts flyash. The lime dosage ranged from 1.1 to 1.4 percent of the total product. The final testing was conducted by varying the amount of pozzolans to water in the waste form. The different water to pozzolans ratios tested were primarily in a range of 0.34 to 0.50.

Mixes were prepared using lime/cement/flyash and lime/cement/flyash plus Latex. The Latex dosage was evaluated at 1, 3, and 5 percent by weight of the cement added. Several other additives were also evaluated because they may be required during remediation. D-Air-2 may be required to reduce foaming in the RCM and the Superplasticizer may be needed to maintain fluidity of the mix during remediation.

Mixes were performed to test the effect of D-Air-2, Superplasticizer, and D-Air-2 with Superplasticizer. The D-Air-2 was added at 0.25% by weight of pozzolans and the Superplastcizer was added at 1.67% by weight of pozzolans. These concentrations were selected based on successful testing on the surrogate waste by Halliburton Services at the Duncan, Oklahoma Research Laboratory. These additions were tested in 207C water, 207C water and silt, and 207C combined with the clarifier sludge.

The testing was conducted on various mixtures of 207C liquid and sludge (i.e., slurries with varying concentrations of suspended solids) and with clarifier sludge combined with the 207C material. The mixtures were prepared in a manner which represents possible processing scenarios during remediation. There are three possible processing scenarios envisioned:

1. 207C water and sludge slurried.

   Currently, it is proposed that the total contents of 207C will be homogenized for remediation and, if necessary, any crystal will be dissolved by diluting the brine water with a fresh water source. It is expected that by doing the above, at worst case the 207C liquid will be saturated and the slurry of combined silty sludge will contain approximately 5 to 10 percent total suspended solids (TSS).

The TDS value will be dependent on the liquid level in the pond at the time of remediation, but will have a maximum TDS value of 35%.

2. 207C slurry combined with clarifier material.

Once the 207C process train is operating properly, then the clarifier slurry will be blended with the 207C slurry. The blending of these two waste streams have the limitation that the combined TSS will not exceed 10 percent, as required by the RCM. When the two waste streams were combined in the laboratory at the expected proportions, analysis of the final mixture indicated that the clarifier contents had a TSS of 5.7 mg/l. This was the highest concentration tested in the laboratory experiments.

3. Wash-down water and any residual solids from Pond 207C.

The final processing scenario will occur toward the end of Pond 207C processing. It is possible that toward the end of processing, only water with very little solids will require treatment. The water will be mostly water used to wash the pond basin free of any residual solids remaining after the bulk of the solids have been removed.

Based on the above scenarios, the following waste forms were prepared for CSS testing in the final phase:

- 207C water and sludge combined at a suspended solids loading from 7 percent to 17 percent.
- 207C water and sludge combined with clarifier contents.
- 207C water with less than 1 percent suspended solids.

The results of the Confirmatory Phase testing are presented in Section 3.0.

2.3 TREATABILITY STUDY TESTING PROCEDURES

2.3.1 Sample Preparation

In general, all of the CSS testing was conducted in a similar fashion. Both Pond 207C and the clarifier contents were chlorinated prior to conducting CSS formula development.

Chlorination/Disinfection

NVO-325 requires that no pathogens, infectious waste, or other etiological agents as defined in Title 49 CFR 173.386 be present in waste accepted at NTS. The definition provided in 49 CFR 173.386 refers to a listing in 42 CFR 72.3. Review of this list suggests that it was developed for packaging and transportation of etiological agents and is not directly applicable to sanitary sewage, the apparent source of biological activity in the pond sludges.

Sanitary wastes were discharged into the solar ponds in past years (Wienand and Howard, 1992). Verification testing of the clarifier sludge and Pond 207C sludge to determine the presence of typical indicator bacteria for sewage was conducted upon receipt of the bulk samples at the HALLIBURTON NUS Laboratory. The testing was conducted to determine if total and fecal coliform were present in the sludge. The results of the testing are provided below:

Matrix	Parameter	Result
Clarifier	Total Coliform	<100 Colonies/100 ml
Clarifier	Fecal Coliform	<300 Colonies/100 ml
Pond 207C	Fecal Coliform	<30 Colonies/100 ml

The values provided above indicate that the results are below detection limits. The detection limits are somewhat elevated because of sample dilutions which are necessary because of the high solids content in the sludge samples. However, the values reported may be false-negatives because the sample holding times were exceeded. The holding time for both total coliform and fecal coliform is 6 hours using Standard Methods 909A and 909C, respectively. The above samples were analyzed approximately one week after collection (samples were shipped by ground transportation from Rocky Flats to Pittsburgh). Although the sample holding times were technically exceeded, which suggest that the data is not conclusive, an argument can be made that there is little difference between the sludge being stored in a sample container compared to remaining in the pond given the length of time since sewage was introduced into the pond.

It should also be noted that the concentration of pathogens in the sludge may have been reduced considerably since the time when sewage was first discharged to the Solar Ponds. Typically, pathogens, mainly those which are highly parasitic, cannot survive for an extended period of time outside of the host-organism (i.e., human body) (Carpenter, 1977). This suggests that the pathogen concentration in the pond sludges has probably decreased over time since sewage has not been discharged into the ponds for several years.

Typically, long-term storage of sludge in ponds results in a decrease in numbers of pathogens. Reductions as high as 99.9 percent have been reported for fecal coliform after 30 days of storage in a sludge lagoon (Environmental Protection Agency, September 1979). Additionally, the conditions found in Pond 207 are not favorable for pathogens associated with sewage sludge because of the high salt content.

Because testing for total and fecal coliform to determine the presence of pathogens was inconclusive because of the holding time issue, a decision was made to disinfect the sludge using calcium hypochlorite. The quantity of chlorinating agent added was based on providing 1 ppm of residual chlorine after 30 minutes of contact time. A residual chlorine concentration of 0.5 mg/l is considered acceptable engineering practice after 15 to 30 minutes of contact time for disinfection of effluents from sewage treatment plants (Corbitt, 1989). The rationale for using residual chlorine to monitor disinfection was necessary because of the inability to verify the presence of fecal coliform in the original sample.

When analysis for residual chlorine was conducted, difficulties were encountered in obtaining an accurate result because of interferences caused by the high salt content in the pond and the yellow color of the pond water. The high salt content interfered with analytical methods which used an ion specific probe and the yellow color of the pond water interfered with calorimetric measurements. The presence of excess chlorine was determined using potassium iodine (KI) paper. This test is qualitative and cannot determine the exact concentration of residual chlorine.

Initial chlorination studies were conducted on 207C/clarifier sludge to evaluate cyanide oxidation, not pathogen destruction. The dosages investigated for cyanide destruction were higher than these needed for pathogen destruction.

Initial chlorination of the clarifier and Pond 207C sludge used a dosage of 7500 ppm calcium hypochlorite to oxidize cyanide (Details of the cyanide oxidation testing are provided in Attachment A-4). This dosage was lowered for the final phase of testing because oxidation of cyanides were deemed unnecessary. The final phase of testing used a calcium hypochlorite dosage of 2000 ppm (based on 100 percent pure product with 70 percent available chlorine). Although actual chlorine analysis was not able to verify that 1 ppm of residual chlorine existed after 30 minutes, it can be inferred from data for Pond 207A/B sludge and by detection of residual chlorine using potassium iodide (KI) paper.

Analysis of residual chlorine from the combined sludges of Pond 207a and the 207B series ponds indicated that a dosage of 208 ppm of calcium hypochlorite resulted in a residual chlorine concentration of approximately 25 ppm after 30 minutes. The dosage for Pond 207C and the clarifier is approximately 10 times higher than the dosage used for the A/B sludge and is believed to be sufficient to result in a residual chlorine concentration in excess of 1 ppm.

The dosage of 2000 ppm of calcium hypochlorite is equivalent to approximately 11.2 pounds/1000 gallons. A dosage of 17 lb/1000 gallons is recommended for disinfection of primary sludge (Environmental Protection Agency, September 1979). This dosage is somewhat higher than the dosage used to disinfect Pond 207C, however, primary sludge would be fresh sewage and would contain a much higher level of pathogens.

In addition to chlorinating the sludge, the mixing of pozzolans with the sludge will increase pH which will also result in disinfection. When the pond sludge and the pozzolans are mixed together, the pH will increase to approximately 12.0 to 12.5. Typically, most bacteria are killed at pH conditions greater than 11 (Weber, 1972).

A final consideration is that the final stabilized waste form will be a solid matrix which will not contain significant amounts of free moisture which is necessary for growth of bacteria. A cement matrix is not an ideal environment for the proliferation of pathogens.

Pozzolan Addition

Each batch for the CSS formulation was prepared by weighing a specified quantity of homogenized waste material (typically 2000 grams). Then the specified quantity of lime was placed in the Hobart mixer with the waste material and mixed for 5 minutes. Then the pozzolans were weighed and mixed with the waste and lime for 5 minutes. After the completion of mixing, the final product was placed in plastic cylinders (2 inch diameter x 4 inch high) for curing. The cylinders were capped and sealed, then placed in Coleman coolers to maintain constant humidity. It should be noted that any temperature fluctuations during curing of the solidified material were not monitored. Curing temperatures were maintained at ambient temperature, which is in accordance with the American Concrete Institute (ACI)specifications for cold and warm weather concrete. The ACI specification (306R-90) for cold weather curing indicates that the temperature must be maintained above 50°F during curing. The ACI specification (305R-89) for hot weather concreting indicates that the temperature should be between 75°F and 100°F to avoid unfavorable effects from heat. The temperature of the treatability laboratory was monitored and was within the above temperature ranges.

Table 2-2 provides a summary of all the batches prepared in the final phase of testing for Pond 207C using a CSS mixture of lime, cement, and flyash. Table 2-3 summarizes the batches prepared for the combined waste stream of the clarifier and Pond 207C. Tables 2-4 and 2-5 summarize the batches prepared using lime, cement, flyash, and the Latex 2000 System for Pond 207C and the combined waste stream of Pond 207C and the clarifier, respectively.

Review of Tables 2-2 through 2-5 indicates that the total suspended solids (TSS) plus the total dissolved solids (TDS) does not always equal the total solids (TS). This could be a result of analytical accuracy or over-lap of solids in both TSS and TDS (i.e., some solids may be recorded as both TSS and TDS). It should be noted that the water to pozzolan ratios were based on the total solids result. The result used for total solids is typically based on the average of duplicate or triplicate analyses.

Cylinder Curing and Testing

After mixing, some specimens were allowed to cure for 7 days and were evaluated for strength (UCS) and metals leachability (TCLP). Other specimens were allowed to cure for 28 days and then evaluated for strength, compliance with LDR

TABLE 2-2

SUMMARY OF 207C WATER AND SILT MIXES
LIME/CEMENT/FLYASH

Batch No. (Date Mixed)	Water/Pozzolan Ratio	Cement/Flyash/Lime Ratio	Total Solids	Total Dissolved Solids	Total Suspended Solids
1. (2/13/92)	0.36	1/2/0.091	40.0%	27.3%	9.3%
2. (2/13/92)	0.42	1/3.34/0.055	40.0%	27.3%	9.3%
3. (2/13/92)	0.44	1/2/0.083	40.0%	27.3%	9.3%
4. (2/13/92)	0.46	1/1.2/0.050	40.0%	27.3%	9.3%
5. (2/13/91)	0.56	1/2/0.065	40.0%	27.3%	9.3%
6. (4/6/92)	0.34	1/2/0.073	38.6%	34.1%	0.89%
7. (4/6/92)	0.42	1/2/0.072	38.6%	34.1%	0.89%
8. (4/6/92)	0.50	1/2/0.077	38.6%	34.1%	0.89%
9. (4/3/92)	0.34	1/2/0.065	35.0%	33.1%	7.4%
10. (4/3/92)	0.42	1/2/0.070	35.0%	33.1%	7.4%
11. (4/3/92)	0.50	1/2/0.076	35.0%	33.1%	7.4%
12. (4/2/92)	0.34	1/2/0.066	38.6%	34.96%	9.1%
13. (4/2/92)	0.38	1/2/0.069	38.6%	34.96%	9.1%
14. (4/2/92)	0.42	1/2/0.072	38.6%	34.96%	9.1%
15. (4/2/92)	0.46	1/2/0.074	38.6%	34.96%	9.1%
16. (4/2/92)	0.50	1/2/0.077	38.6%	34.96%	9.1%
17. (4/2/92)	0.42	1/2/0.074	44.0%	40.4%	9.1%
18. (4/2/92)	0.50	1/2/0.080	44.0%	40.4%	9.1%
19. (4/3/92)	0.38	1/2/0.071	43.4%	32.1%	11.3%
20. (4/3/92)	0.42	1/2/0.074	43.4%	32.1%	11.3%
21. (4/3/92)	0.48	1/2/0.079	43.4%	32.1%	11.3%
22. (4/3/92)	0.34	1/2/0.071	49.1%	31.9%	17.2%
23. (4/3/92)	0.42	1/2/0.078	49.1%	31.9%	17.2%
24. (4/3/92)	0.50	1/2/0.084	49.1%	31.9%	17.2%
25. (5/13/92)(1)	0.42	1/2/0.070	35.0%	33.1%	7.4%
26. (5/13/92(2)	0.42	1/2/0.070	35.0%	33.1%	7.4%
27. (5/13/92)(3)	0.42	1/2/0.070	35.0%	33.5%	7.4%
28. (5/13/92)(4)	0.42	1/2/0.072	38.6%	34.1	0.9%
29. (5/13/92)(3)	0.42	1/2/0.072	38.6%	34.1%	0.9%
30. (5/13/92)(6)	0.42	1/2/0.072	38.6%	34.1%	0.9%

TABLE 2-2
SUMMARY OF 207C WATER AND SILT MIXES
LIME/CEMENT/FLYASH
PAGE TWO

NOTE: Supporting information for Total Solids, Total Dissolved Solids, and Total Suspended Solids is provided in Attachment D.

(1) Additive Mixture: Added D-Air-2 at 0.25% of total pozzolan weight.
(2) Additive Mixture: Added superplasticizer at 1.67% by weight of pozzolan.
(3) Additive Mixture: Added D-Air-2 at 0.25% and superplasticizer at 1.67% by weight of pozzolans.
(4) Additive Mixture: Added D-Air-2 at 0.25% by weight of pozzolans.
(5) Additive Mixture: Added superplasticizer at 1.67% by weight of pozzolans.
(6) Additive Mixture: Added D-Air-2 at 0.25% and superplasticizer at 1.67% at total by weight of pozzolans.

TABLE 2-3

SUMMARY OF POND 207C AND CLARIFIER MIXES
LIME/CEMENT/FLYASH

Batch No. (Date Mixed)	Water/Pozzolan Ratio	Cement/Flyash/Lime Ratio	Total Solids	Total Dissolved Solids	Total Suspended Solids
1C (4/1/92)	0.34	1/2/0.065	33.8%	27.4%	11.0%
2C (4/1/92)	0.42	1/2/0.070	33.8%	27.4%	11.0%
3C (4/1/92)	0.50	1/2/0.076	33.8%	27.4%	11.0%
4C (4/6/92)	0.34	1/2/0.066	38.9%	34.6%	11.6%
5C (4/6/92)	0.38	1/2/0.078	38.9%	34.6%	11.6%
6C (4/6/92)	0.42	1/2/0.072	38.9%	34.6%	11.6%
7C (4/6/92)	0.46	1/2/0.067	38.9%	34.6%	11.6%
8C (4/6/92)	0.50	1/2/0.077	38.9%	34.6%	11.6%
9C (4/6/92)	0.50	1/1/0.052	38.9%	34.6%	11.6%
10C (4/6/92)	0.34	1/0/0.022	38.9%	34.6%	11.6%
11C (4/6/92)	0.38	1/0/0.023	38.9%	34.6%	11.6%
12C (4/6/92)	0.42	1/0/0.024	38.9%	34.6%	11.6%
13C (4/6/92)	0.46	1/0/0.025	38.9%	34.6%	11.6%
14C (4/6/92)	0.50	1/0/0.026	38.9%	34.6%	11.6%
15C (5/13/92)(1)	0.42	1/2/0.072	38.9%	34.6%	11.6%
16C (5/13/92)(2)	0.42	1/2/0.072	38.9%	34.6%	11.6%
17C (5/13/92)(3)	0.42	1/2/0.072	38.9%	34.6%	11.6%

NOTE: Supporting information provided in Attachment D for Total Solids, Total Dissolved Solids, and Total Suspended Solids.

(1) Additive Mixture: Added D-Air-2 at 0.25% by weight of pozzolans.
(2) Additive Mixture: Added superplasticizer at 1.67% by weight of pozzolans.
(3) Additive Mixture: Added D-Air-2 at 0.25% and superplasticizer of 1.67% by weight of pozzolans.

TABLE 2-4

SUMMARY OF 207C WATER AND SILT MIXES
LIME/CEMENT/FLYASH/LATEX

Batch No. (Date Mixed)	Water/Pozzolan Ratio	Cement/Flyash/Lime Ratio	Latex Dosage	Total Solids	Total Dissolved Solids	Total Suspended Solids
1L (2/13/92)	0.42	1/3.33/0.091	1%	40.0%	27.3%	9.3%
2L (2/13/92)	0.36	1/2/0.055	1%	40.0%	27.3%	9.3%
3L (2/13/92)	0.56	1/2/0.083	1%	40.0%	27.3%	9.3%
4L (2/13/92)	0.46	1/1.2/0.050	1%	40.0%	27.3%	9.3%
5L (2/13/91)	0.44	1/2/0.065	3%	40.0%	27.3%	9.3%
6L (2/13/92)	0.42	1/3.33/0.091	5%	40.0%	27.3%	9.3%
7L (2/13/92)	0.36	1/2/0.055	5%	40.0%	27.3%	9.3%
8L (2/13/92)	0.56	1/2/0.083	5%	40.0%	27.3%	9.3%
9L (2/13/92)	0.46	1/1.2/0.050	5%	40.0%	27.3%	9.3%
10L (4/2/92)	0.5	1/2/0.077	1%	38.6%	34.96%	9.1%
11L (4/2/92)	0.5	1/2/0.078	5%	38.6%	34.96%	9.1%
12L (4/2/92)	0.34	1/2/0.066	1%	38.6%	34.96%	9.1%
13L (4/2/92)	0.34	1/2/0.067	5%	38.6%	34.96%	9.1%
14L (4/2/92)	0.42	1/2/0.072	3%	38.6%	34.96%	9.1%
15L (4/3/92)	0.50	1/2/0.078	3%	35.0%	33.1%	7.4%
16L (4/3/92)	0.34	1/2/0.067	3%	35.0%	33.1%	7.4%
17L (4/3/92)	0.42	1/2/0.075	3%	43.4%	32.1%	11.3%
18L (4/3/92)	0.50	1/2/0.085	3%	49.1%	31.9%	17.2%
19L (4/3/92)	0.34	1/2/0.071	3%	49.1%	31.9%	17.2%

NOTE: Supporting information provided in Attachment D for Total Solids, Total Dissolved Solids, and Total Suspended Solids.

TABLE 2-5

SUMMARY OF 207C AND CLARIFIER MIXES
LIME/CEMENT/FLYASH/LATEX

Batch No. (Date Mixed)	Water/Pozzolan Ratio	Cement/Flyash/Lime Ratio	Latex Dosage	Total Solids	Total Dissolved Solids	Total Suspended Solids
1CL (4/6/92)	0.34	1/2/0.066	5%	38.9%	34.6%	11.6%
2CL (4/6/92)	0.42	1/2/0.078	3%	38.9%	34.6%	11.6%
3CL (4/6/92)	0.34	1/2/0.072	1%	38.9%	34.6%	11.6%
4CL (4/6/92)	0.50	1/2/0.067	5%	38.9%	34.6%	11.6%
5CL (4/6/92	0.50	1/2/0.077	1%	38.9%	34.6%	11.6%

NOTE: Supporting information provided in Attachment D for Total Solids, Total Dissolved Solids, and Total Suspended Solids.

treatment standards (TCLP and analysis for inorganics and organics of concern), free liquid criteria (paint filter liquids test and liquid/solids test) and durability (wet/dry and freeze/thaw resistance). Only the batches prepared at a 0.42 water/pozzolan ratio were tested for volatile organics after the TCLP Zero Head-Space Extraction (ZHE). Specimens that were subjected to wet/dry and freeze/thaw tests were also evaluated for strength to determine whether a decrease in strength had occurred. Additional details of the analysis program are provided in Section 2.3.3.

Petrographic analysis of the test cylinders was also conducted to determine if certain parameters had a microscopic effect on the final product. The main parameter of concern, that was evaluated, was the effect of latex on crystal growth. Additional parameters which were evaluated included suspended solids loading, salt loading, and variation of the water to pozzolan ratio. Details of the results of petrographic analysis are provided in section 3.1.2.3.

2.3.2 Equipment and Materials

2.3.2.1 Mixed-Waste Treatability Study Laboratory

The testing conducted for the Pond 207C/Clarifier CSS treatability study was performed at the HALLIBURTON NUS Laboratory in Pittsburgh, Pennsylvania. The work was performed in a treatability room that was specifically designed to accommodate low-level mixed waste materials. The room has double air locks for entrance and exit along with a negative air ventilation system which exhausts air through HEPA filters. All personnel entering this secured area are required to wear personnel protective equipment (Tyvek coverall, booties, and latex gloves). Personnel must also wear dosimetry badges and rings. Additionally, all personnel must also submit quarterly bioassays for radionuclide analysis.

2.3.2.2 Laboratory Equipment

All major equipment used for the solidification portions of the treatability study is provided in Table 2-6. This table provides the manufacturer, model number and the pertinent specification for the equipment.

TABLE 2-6

EQUIPMENT SUMMARY

Equipment	Manufacturer	Model No.	Pertinent Specifications
Mixer	Hobart	N-50	Motor Rating: 1/6 HP, 1725 RPM, Single Phase, 115V., 60 Hz, 2.85 Amps
Unconfined Compressive Strength	Geotest Instrument Corporation	S2013	Max. Load Ring = 2000 lb.
Accelerated Cure Bath	CURAMOLD	6BA	Temperature Rating 95°F ±5°F
Drying Oven (freeze/thaw and liquid/solids tests)	Fisher Scientific	655F	Accuracy ±2°F
Freezer	Revco	Ult 1340-5-AVA	Accuracy ±2°F

2.3.2.3 CSS Material Specifications

The materials used for the CSS formulas include cement, flyash, lime, and materials for the HALLIBURTON Latex 2000 system. For all of the testing, the same type of materials were used.

The lime used was a high calcium hydrated lime manufactured by Center Lime and Stone Inc., Pleasant Gap, Pennsylvania. The typical specifications for a high calcium hydrated lime are as follows:

- Specific Gravity - 2.3 to 2.4
- Bulk Density - 25 to 35 lb./cu. ft.
- Specific Heat at 100° F. - 0.29 Btu/lb.
- Contains less than 5% magnesium oxide
- Contains less than 1% unhydrated oxides

The cement used for the CSS formula development is classified as Type V as per ASTM C-150. Type V cement is used when there is potential for sulfate attack, either internally of externally. It is recommended that Type V cement be used if sulfate concentrations in water are between 1,500 to 10,000 ppm (Portland Cement Association, 1979). The concentration of the clarifier water and 207C pond water are 2,600 to 3,200 mg/l and 16,000 to 18,000 mg/l, respectively

(HALLIBURTON NUS, 1992). Therefore, the use of Type V cement is considered necessary.

Typically, sulfate attack is only thought to be a concern for cement which is subjected to external sulfate attack from groundwater or where the reinforcing in concrete structures will corrode when exposed to high sulfate concentrations in the mixing water. However, internal attack from sulfate will cause expansion and cracking of the matrix resulting in loss of strength and disruption. Expansion is caused by sulfate ions reacting with tricalcium aluminate (C_3A) which forms ettringite (Ouyang, Nanni, and Chang, 1988). To improve resistance to sulfate attack, a cement which is low in C_3A should be used. Less than 7.0 percent C_3A is recommended. The ASTM standard (ASTM C 150-89) for Type V portland cement is less than 5 percent for C_3A content, and therefore should reduce the potential for deterioration of the final product from internal sulfate attack.

The primary difference between Type V and Type I cement is the amount of C_3A in the cement. Type V cement specifies a maximum of 5% C_3A, whereas Type I has no maximum. The cement used in the treatability study was obtained from Mountain Cement Company located in Laramie, Wyoming. A Product Specification Sheet is provided in Attachment B. Also shown in Attachment B are the results for gross alpha and gross beta analysis for the cement.

The flyash that was used for the CSS formulas was Type C, which meets the ASTM C618 specification. Two different sources of Type C flyash were used, both supplied by the Western Ash Company. One was from the Comanche power plant, and the other was from the Pawnee power plant. The Pawnee flyash was used for the majority of the testing. The two flyashes are similar in chemical make-up, as shown by the analyses on the Product Specification Sheets provided in Attachment B.

The Halliburton Latex 2000 System includes a latex additive, D-Air 3, and Stabilizer 434C. The D-Air 3 is a defoamer and the Stabilizer 434C is a surfactant. All three products are proprietary.

Two other Halliburton products which were used during the treatability study are D-Air-2 and a Superplasticizer. The D-Air-2 is a defoamer and may be required during remediation to reduce foaming in the RCM. Superplasticizer may be needed during remediation to ensure that the pozzolan mixture remains fluid.

2.3.3 Analytical Program

Throughout the treatability study, samples were collected and analyzed to assess the CSS formulations. Samples of stabilized waste were collected at the end of predetermined curing times, either 48 hours, 7 days, or 28 days. Samples were collected by removing the stabilized waste from the plastic curing cylinder by cutting the plastic cylinder. The cured cylinders were hand-carried to the laboratory log-in area where each sample was assigned a laboratory tracking number. After samples received a tracking number, standard laboratory chain-of-custody procedures were followed as described in the HALLIBURTON NUS Laboratory General Quality Assurance Manual.

Only those analysis which are required for final product certification are analyzed by SW-846 with deliverables similar to CLP-type deliverables. This primarily refers to those analyses conducted for the LDR final phase with the intention that these data will be legally defensible. All other analysis were conducted according to SW-846, but where analyzed with the intention of being used for engineering data (i.e., CLP-like deliverables are not provided and data is not validated)

The analytical program for the final phase of CSS testing is provided in Table 2-7. The rationale for each analysis is provided below.

- Unconfined compressive strength (UCS) provides an estimate of the final product's strength and allows comparisons with other formulations. Although direct correlations cannot be drawn between strength and any of the LDR or free liquid requirements, UCS results that approach 600 psi have typically passed the durability testing.

- TCLP analysis for RCRA metals plus nickel are required to ensure that the final waste form meets the LDR requirements as regulated by 40 CFR 268.41 and toxicity characteristic criteria regulated by 40 CFR 261.24. The toxicity characteristic metals such as arsenic and cadmium are required because their toxicity characteristic concentrations were exceeded in the raw waste. Cadmium, chromium, lead, nickel, and silver are regulated by F006, F007, and F009 wastes, and are therefore required to verify that they leach below the LDR limits.

TABLE 2-7

SUMMARY OF TESTING FOR
FINAL PHASE
POND 207C AND CLARIFIER CSS TREATABILITY STUDY
ROCKY FLATS PLANT, COLORADO

Analysis	Method	Sampled After 7 Days of Curing	Sampled After 28 Days of Curing
Unconfined Compressive Strength (UCS)	ASTM D4219-83	Yes	Yes
TCLP-RCRA Metals and Nickel (1)	SW 3010/6010	Yes	Yes
Total and Amenable Cyanide on TCLP Leachate	ASTM D2036	Yes	Yes
TCLP/ZHE Selected Volatile Organics (2)	SW 8240	No	Yes(3)
Gross Alpha and Gross Beta on TCLP Leachate	EPA 900.0	Yes	No
Standard Test Methods for Wetting and Drying Compacted Soil-Cement Mixtures (Wet/Dry) and UCS on cylinder following test	ASTM D559-82 and C39-86	No	Yes(4)
Standard Test Methods for Freezing and Thawing Compacted Soil-Cement Mixtures (Freeze/Thaw) and UCS on cylinder following test	ASTM D560-82 and C39-86	No	Yes(4)
Paint Filter Liquids Test	SW 9095	No	Yes
Standard Test Methods for Determining Whether a Material is a Liquid or a Solid (Liquid/Solids Test)	ASTM D4359-84	No	Yes
Petrographic Analysis	ASTM C856-77	No	Yes

(1) TCLP METALS

Arsenic
Barium
Cadmium
Chromium
Lead
Mercury
Nickel
Selenium
Silver

(2) TCLP/ZHE VOLATILES

Benzene
2-Butanone
Carbon tetrachloride
Chlorobenzene
Chloroform
1,2-Dichloroethane
1,1-Dichloroethene
Tetrachloroethene
Trichloroethene
Vinyl Chloride

(3) Zero Headspace Extraction (ZHE) Volatile organic analysis was conducted on those batches had a water to pozzolan ratio of 0.42.

(4) Unconfined compressive strength testing was conducted after the durability testing to enable evaluation of reduction of strength because of the sever conditions of the durability tests.

- Cyanide (total and amenable) was analyzed in the TCLP extract because it is a constituent of F006, F007, and F009 wastes. Although cyanide is regulated as a contaminant concentration in the waste (CCW) constituent and not a contaminant concentration in the waste extract (CCWE) constituent, it was analyzed in the TCLP extract to provide data on its leaching characteristics. This information is not required for waste certification.

- Analysis for the LDR-regulated volatile organics was conducted as a verification that these organics are below the LDR criteria as required in 40 CFR 268.41. All of the volatile organic compounds which are regulated by 40 CFR 268 for F001, F002, F003, and F005 wastes were not analyzed. Only the volatiles which had positive detections during past sampling episodes were analyzed. Because the characterization report indicated that none of the organics of concern were detected at concentrations above the LDR criteria, TCLP/ZHE volatile organic analysis was only conducted on several batches as a verification that the organics are below RCRA LDR requirements.

- Gross alpha and gross beta were analyzed on the TCLP leachate of the final products for 7-day cured samples. These results were used to determine if the TCLP extracts of stabilized 207C/clarifier waste could be shipped from Rocky Flats to an off-site laboratory for testing during remediation. However, it is no longer intended to ship leachates off-site for analysis. The entire cylinder will be sent off-site for analysis during remediation (Details of radiation and shipping requirements are provided in Attachment E).

- The Paint Filter Test and the liquid/solids test are required to determine if the final product can be shipped as a solid and to verify that there are no free liquids present.

- Petrographic analysis provided qualitative microscopic evaluation of the stabilized waste to help evaluate CSS performance and to determine if the mixtures had any defects that are not apparent or revealed by the regulatory or durability testing. This testing also provided an indication of whether the addition of latex produced a significantly better final product.

2.3.3.1 Durability Testing Procedure

Durability testing was conducted following ASTM Methods D559-82 and D560-82 for the wet/dry and freeze/thaw testing, respectively. These methods were selected over ASTM Methods D4843-88 and D4842-90. The first two methods were considered more stringent than the last two methods. The following sections compare the methods for durability testing.

2.3.3.1.1 Comparison of Freezing and Thawing Test Methods

Two ASTM methods for Freezing and Thawing of material were evaluated to determine which ASTM method to use for testing. The methods compared were ASTM Method D560-82, Standard Methods for Freezing-and-Thawing Tests of Compacted Soil-Cement Mixtures, and ASTM Method D4842-90, Standard Test Method for Determining the Resistance of Solid Wastes to Freezing and Thawing, as shown in Table 2-8.

Method D560-82 utilizes two specimens, one is a "control" and the other is a "scratch". The specimens are cycled for a series of twelve 48-hour periods; 24 hours in a freezing cabinet at -23°C, and then placed in a moist room for 23 hours at 21°C and relative humidity of 100 percent. After each cycle, the "scratch" specimen is stroked longitudinally, covering all areas twice, with a wire brush. The control specimen offers data based on the changes in moisture content and volume over the 12 cycles, whereas the scratch specimen offers data regarding the waste-cement loss of the specimen. Although ASTM Method D560-82 does not dictate the failure point of each specimen, it is felt that failure can be determined based on a visual assessment of the scratched sample and the control sample. Failure is considered to be the point at which the specimen breaks apart.

Method D4842-90 utilizes six specimens, three are "control" and three are for "testing". The "control" specimens are cycled for a series of twelve 48-hour periods; 24 hours in a moisture chamber at 20°C, and 23 hours submerged in room temperature water. The "testing" specimens are also cycled for twelve 48-hour periods; 24 hours in a freezing chamber at -20°C and 23 hours submerged in water at 4°C. At the end of each cycle, mass loss is calculated by evaporating the water used for submersion of the specimens and weighing the residual solids. A specimen is considered to have failed when its mass loss exceeds 30 percent.

TABLE 2-8

ASTM METHOD SUMMARY
FREEZE/THAW DURABILITY TESTS

Item	Method D560-82	Method D4842-90
No. of Control Specimens	1	3
No. of Test Specimens	1	3
Number of Cycles	12	12
Cycle Time	48 Hrs	48 Hrs
Max. Cycle Temp.	21°C	4°C
Min. Cycle Temp.	-23°C	-20°C
Defined Failure Point	NA*	30% Mass Loss

* - Failure of specimen is determined visually. The specimen is considered a failure when it breaks apart.

Although ASTM Method D4842-90 is established for testing of solid waste, the preferred method for testing is ASTM Method D560-82. ASTM Method D560-82 cycles both the control and scratch specimens over a broader temperature range than in Method D4842-90. Also, in ASTM Method D560-82, the scratch specimen undergoes a more rigorous cycle than the specimens in Method D4842-90, thus allowing a better basis of determining adequate water to pozzolan ratios needed to achieve long-term durability.

2.3.3.1.2 Comparison of Wetting and Drying Test Methods

Two ASTM methods for Wetting and Drying of material were evaluated to determine which of ASTM method to use for testing. The methods compared were ASTM Method D559-82, Standard Methods for Wetting-and-Drying Tests of Compacted Soil-Cement Mixtures, and ASTM Method D4843-88, Standard Test Method for Wetting and Drying Test of Solid Wastes, as shown in Table 2-9.

Method D559-82 utilizes two specimens, one is a "control" and the other is a "scratch". The specimens are cycled for a series of twelve 48-hour periods; submerged for 5 hours at room temperature in potable water and then placed in an oven for 42 hours at 71°C, after which the "scratch" specimen is stroked longitudinally, covering all areas twice, with a wire brush. The control specimen offers data based on the changes in moisture content and volume over the twelve cycles, whereas the scratch specimen offers data regarding the waste-cement loss of the specimen. Although ASTM Method D559-82 does not dictate the failure point of each specimen, it is felt that failure can be determined based on a visual assessment of the scratched sample and the control sample. Failure is considered to be the point at which the specimen breaks apart.

Method D4843-88 utilizes six specimens, three are "control" and three are for "testing". The "control" specimens are cycled for a series of twelve 48-hour periods; 24 hours in a moisture chamber at 20°C, 1 hour of cooling time, and 23 hours submerged in distilled water at 20°C. The "testing" specimens are also cycled for twelve 48-hour periods; 24 hours at 60°C in an oven purged with nitrogen, 1 hour cooling time, and 23 hours submerged in distilled water at 20°C. At the end of each cycle, mass loss is calculated by evaporating the distilled water used for submersion of the specimens and weighing the residual solids. A specimen is considered to have failed when its mass loss exceeds 30 percent.

TABLE 2-9

ASTM METHOD SUMMARY
WET/DRY DURABILITY TESTS

Item	Method D559-82	Method D4843-88
No. of Control Specimens	1	3
No. of Test Specimens	1	3
Number of Cycles	12	12
Cycle Time	48 Hrs	48 Hrs
Max. Cycle Temp.	71°C	60°C
Min. Cycle Temp.	Room Temp.	20°C
Defined Failure Point	NA*	30% Mass Loss

* - Failure of specimen is determined visually. The specimen is considered a failure when it breaks apart.

Although ASTM Method D4843-88 is established for testing of solid waste, the preferred method for testing is ASTM Method D559-82. In ASTM Method D559-82, the scratch specimen undergoes a more rigorous cycle than the specimens in Method

D4843-88, thus allowing a better basis of determining adequate water to pozzolan ratios needed to achieve long-term durability.

2.4 Data Validation and Evaluation

All laboratory analytical data which were required for final product certification were subjected to the process of data validation. Formal data validation is a systematic review and evaluation of data that serves as an independent QA check of the laboratory results. It is also a means of evaluating laboratory performance and determining the impact, if any, of noncompliances on the data. Through the use of data qualifiers, validation lends interpretive guidance concerning proper usage and limitations of the data.

Data validation was conducted in accordance with the EPA "Laboratory Data Validation Functional Guidelines for Evaluating Inorganic Analyses" and "Laboratory Data Validation Functional Guidelines for Evaluating Organic Analyses," as applied for use within EPA Region VIII. The validation performed on the treatability study samples was the same as that performed on Contract Laboratory Protocol (CLP) samples.

Internal memoranda documenting the validation process were prepared and are included in Attachment C. These memoranda explain the findings of the validation process, interpret the actions taken on the data, and summarize the data qualifiers assigned. The results of the validation process have been entered into the data tables provided in Section 3.0.

Summary tables were prepared for all of the data generated in the final phase to facilitate review and interpretation of the data. These tables are included in Section 3.0.

3.0 RESULTS AND DISCUSSION

Section 3.1 provides the results of all of the testing conducted for the final phase (III/IV regulatory confirmation phase) of the treatability study for Pond 207C and the Clarifier. Sections 3.2 and 3.3 discuss applying the results of testing to the Process Control Plan and development of an operating range of key process control parameters for the lime/cement/flyash CSS formula, and the lime/cement/flyash plus latex CSS formula, respectively. Section 3.4 provides information on the process formulations and operating ranges.

3.1 FINAL PHASE TREATABILITY STUDY RESULTS

The analytical data generated during the final, regulatory confirmation phase of the treatability study are divided into two groups. The first group consists of data from tests which are required for certification of the final waste product. These tests include those concerning the LDR criteria and free liquid criteria. The second group consists of data for engineering parameters such as UCS, wet/dry durability, and freeze/thaw durability.

3.1.1 Results of Regulatory Testing

3.1.1.1 TCLP Metals/Cyanides/Radiological Results

The analytical results for the TCLP metals, cyanide, and gross alpha and gross beta in the TCLP leachate are provided in this section. Tables 3-1A to 3-1I provide the analytical results for Pond 207C water and silt mixes with lime, cement, and flyash. The analytical results for Pond 207C slurry (water and silt) and the Clarifier mixed with lime, cement, and flyash are provided in Tables 3-2A to 3-2D. Tables 3-3A to 3-3C provide the analytical results for Pond 207C water and silt mixed with lime, cement, flyash, and Latex 2000. Table 3-4 provides the analytical results for Pond 207C slurry and the Clarifier mixed with lime, cement, flyash, and Latex 2000. All of the data presented in Tables 3-1A to 3-4 has been validated unless otherwise noted (Validation Letters are provided in Attachment B).

Review of the TCLP results indicates that all leachate concentrations for all of the batches in Tables 3-1A to 3-4 are below the criteria for the RCRA characteristic of toxicity (40 CFR 261.24) and the criteria for the RCRA Land Ban Restrictions (40 CFR 268.41) with one exception. The 7-day concentration for lead in the TCLP leachate for Batch 15 was 569 ug/l, which is above the LDR

TABLE 3-1A
POND 207C WATER AND SILT
LIME, CEMENT, AND FLYASH
TCLP (UG/L)

Analyte	Batch 1 2/13/92(1)		Batch 2 2/13/92(1)		Batch 3 2/13/92(1)		Batch 4 2/13/92(1)		Batch 5 2/13/92(1)		TC Standard(2)	LDR Standard(3)
	7 Day	28 Day	7 Day	28 Day	7 Day	28 Day	7 Day	28 Day	7 Day	28 Day		
Aluminum	NA	15000	NA	2230	NA	8080	NA	2280	NA	4430	NS	NS
Arsenic	<70.0	87.0	<70.0	105	110	173	<70.0	106	90	126	5,000	NS
Barium	720	568	800	597	640	469	760	511	610	583	100,000	NS
Cadmium	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	1,000	66
Calcium	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NS	NS
Chromium	280	267	260	215	340	300	340	311	320	288	5,000	5,200
Iron	NA	<20.0	NA	<20.0	NA	<20.0	NA	<20.0	NA	23.0	NS	NS
Lead	<30.0	<30.0	<30.0	<30.0	<30.0	<30.0	<30.0	<30.0	<30.0	<30.0	5,000	510
Magnesium	NA	278	NA	162	NA	141	NA	126	NA	159	NS	NS
Mercury	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	200	NS
Nickel	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0	NS	320
Selenium	60.0	53.0	<50.0	<50.0	<50.0	<50.0	<50.0	<50.0	<20.0	<50.0	1,000	NS
Silver	<5.0	<5.0UJ	<5.0	<5.0UJ	<5.0	<5.0UJ	<5.0	<5.0UJ	<5.0	<5.0UJ	5,000	72
Total Cyanide	NA	15	NA	<12	NA	15	NA	13	NA	18	NS	NS
Amen. Cyanide	NA	-21	NA	-43	NA	-1,300	NA	-91	NA	-1,300	NS	NS
pH	11.2	11.0	11.7	11.6	11.4	11.3	11.7	11.6	11.5	11.5	NS	NS

(1) Date when batch was mixed.
(2) TC Standard - Standards for metal compounds regulated by 40 CFR 261.24 for the characteristic of toxicity.
(3) LDR Standard - Standard for metal compounds regulated by 40 CFR 268 for F006, F007, and F009.

NA - Not Analyzed
NS - No Standard
UJ - Estimated Non-detection

TABLE 3-1B
POND 207C WATER AND SILT
LIME, CEMENT, AND FLYASH
TCLP (UG/L)

Analyte	Batch 6 4/6/92(1)		Batch 7 4/6/92(1)		Batch 8 6/6/92(1)		TC Standard(2)	LDR Standard(3)
	7 Day	28 Day	7 Day	28 Day	7 Day	28 Day		
Aluminum	2840	2500	3360	3710	3760	4180	NS	NS
Arsenic	<70.0	<70.0	<70.0	90.0	<70.0	91.0	5,000	NS
Barium	679	662	655	662	611	591	100,000	NS
Cadmium	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	1,000	66
Calcium	1.74×10^6	1.83×10^6	1.75×10^6	1.77×10^6	1.73×10^6	$1,81 \times 10^6$	NS	NS
Chromium	237	225	252	241	275	242	5,000	5,200
Iron	207	33.0	<2.0	<20.0	58.0U	<20.0	NS	NS
Lead	<30.0	<30.0	<30.0	<30.0	<30.0	<30.0	5,000	510
Magnesium	191U	92.0	225U	131	159U	117	NS	NS
Mercury	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	200	NS
Nickel	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0	NS	320
Selenium	<50.0	<50.0	<50.0	<50.0	<50.0	<50.0	1,000	NS
Silver	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	5,000	72
Total Cyanide	18	<12	17	14	19	15	NS	NS
Amen. Cyanide	-950	-120	-730	-220	-3,000	-910	NS	NS
pH	11.4	11.5	11.3	11.3	11.4	11.3	NS	NS
Total Alpha	<200 pCi/L	NA	<200 pCi/L	NA	<200 pCi/L	NA	NS	NS
Total Beta	440±100 pCi/L	NA	500±100 pCi/L	NA	540±110 pCi/L	NA	NS	NS

(1) Date when batch was mixed.
(2) TC Standard - Standards for metal compounds regulated by 40 CFR 261.24 for the characteristic of toxicity.
(3) LDR Standard - Standard for metal compounds regulated by 40 CFR 268 for F006, F007, and F009.

NS - No Standard
U - Not detected. Value represents elevated detection limit determined during data validation.

TABLE 3-1C
POND 207C WATER AND SILT
LIME, CEMENT, AND FLYASH
TCLP (UG/L)

Analyte	Batch 9 4/3/92(1)		Batch 10 4/3/92(1)		Batch 11 4/3/92(1)		TC Standard(2)	LDR Standard(3)
	7 Day	28 Day	7 Day	28 Day	7 Day	28 Day		
Aluminum	1880	2790	1450	3010	3110	3990	NS	NS
Arsenic	<70.0	120	<70.0	150	131	109	5,000	NS
Barium	808	602	728	558	643	565	100,000	NS
Cadmium	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	1,000	66
Calcium	1.81×10^6	1.79×10^6	1.69×10^6	1.8×10^6	1.71×10^6	1.79×10^6	NS	NS
Chromium	198	214	221	218	263	242	5,000	5,200
Iron	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0	NS	NS
Lead	<30.0	<30.0	<30.0	<30.0	<30.0	35.0	5,000	510
Magnesium	172	259	135	205	166	203	NS	NS
Mercury	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	200	NS
Nickel	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0	NS	320
Selenium	<50.0	77.0	<50.0	72.0	<50.0	<50.0	1,000	NS
Silver	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	5,000	72
Total Cyanide	16	26J	15	24J	24	18J	NS	NS
Amen. Cyanide	-2,200	R	-2,000	R	-2,700	R	NS	NS
pH	11.5	11.3	11.6	11.4	11.4	11.4	NS	NS
Gross Alpha	<200 pCi/L	NA	<200 pCi/L	NA	<200 pCi/L	NA	NS	NS
Gross Beta	450±100 pCi/L	NA	560±100 pCi/L	NA	510±100 pCi/L	NA	NS	NS

(1) Date when batch was mixed.
(2) TC Standard - Standards for metal compounds regulated by 40 CFR 261.24 for the characteristic of toxicity.
(3) LDR Standard - Standard for metal compounds regulated by 40 CFR 268 for F006, F007, and F009.

NS - No Standard
NA - Not Analyzed
J - Estimated
R - Rejected

TABLE 3-1D
POND 207C WATER AND SILT
LIME, CEMENT, AND FLYASH
TCLP (UG/L)

Analyte	Batch 12 4/2/92(1)		Batch 13 4/2/92(1)		Batch 14 4/2/92(1)		Batch 15 (4/2/92(1)		Batch 16 4/2/92(1)		TC Standard(2)	LDR Standard(3)
	7 Day	28 Day	7 Day	28 Day	7 Day	28 Day	7 Day	28 Day	7 Day	28 Day		
Aluminum	1320	2150	2050	2890	1810	3710	3280	5860	3590	6530	NS	NS
Arsenic	<70.0	99.0	<70.0	120	<70.0	117	80.0	80.0	87.0	139	5,000	NS
Barium	770	657	661	721	827	608	650	504	659	471	100,000	NS
Cadmium	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	1,000	66
Calcium	1.73×10^6	1.72×10^6	1.79×10^6	0.82×10^6	1.59×10^6	1.63×10^6	1.66×10^6	1.65×10^6	1.66×10^6	1.66×10^6	NS	NS
Chromium	138	155	144	148	147	156	194	187	216	209	5,000	5,200
Iron	<20.0	<20.0	<20.0	20.0	27.0	<20.0	33.0	<20.0	<20.0	<20.0	NS	NS
Lead	<30.0	<30.0	<30.0	<30.0	<30.0	<30.0	569	<30.0	<30.0	<30.0	5,000	510
Magnesium	171	159	170	161	167	172	176	169	162	156	NS	NS
Mercury	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	200	NS
Nickel	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0	NS	320
Selenium	<50.0	62.0	<50.0	54.0	<50.0	96.0	<50.0	<50.0	<50.0	<50.0	5,700	NS
Silver	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	5,000	72
Total Cyanide	14	25	<12	18	<12	16	18	19	<12	13	NS	NS
Amen. Cyanide	-1,100	-19	-280	-1900	-46	-810	-200	-750	-1,100	-1800	NS	NS
pH	10.8	11.3	10.6	11.3	11.0	11.2	10.5	11.2	10.9	11.2	NS	NS
Gross Alpha	<200 pCi/L	NA	<200 pCi/L	NA	<200 pCi/L	NA	<200 pCi/L	NA	<200 pCi/L	NA	NS	NS
Gross Beta	570±100 pCi/L	NA	410±90 pCi/L	NA	690±110 pCi/L	NA	520±100 pCi/L	NA	<600±110 pCi/L	NA	NS	NS

(1) Date when batch was mixed.
(2) TC Standard - Standards for metal compounds regulated by 40 CFR 261.24 for the characteristic of toxicity.
(3) LDR Standard - Standard for metal compounds regulated by 40 CFR 268 for F006, F007, and F009.

NS - No Standard
NA - Not Analyzed

TABLE 3-1E
POND 207C WATER AND SILT
LIME, CEMENT, AND FLYASH
TCLP (UG/L)

Analyte	Batch 17 4/2/92(1) 7 Day	Batch 17 4/2/92(1) 28 Day	Batch 18 4/2/92(1) 7 Day	Batch 18 4/2/92(1) 28 Day	TC Standard(2)	LDR Standard(3)
Aluminum	3390	5410	3360	7060	NS	NS
Arsenic	<70.0	116	83.0	98.0	5,000	NS
Barium	591	483	634	473	100,000	NS
Cadmium	<5.0	<5.0	<5.0	<5.0	1,000	66
Calcium	1.64×10^6	1.69×10^6	1.62×10^6	1.67×10^6	NS	NS
Chromium	209	192	211	196	5,000	5,200
Iron	<20.0	<20.0	<20.0	<20.0	NS	NS
Lead	<30.0	<30.0	<30.0	<30.0	5,000	510
Magnesium	137	163	161	160	NS	NS
Mercury	<0.2	<0.2	<0.2	<0.2	200	NS
Nickel	<20.0	<20.0	<20.0	<20.0	NS	320
Selenium	<50.0	74.0	51	59.0	5,700	NS
Silver	<5.0	<5.0	<5.0	<5.0	5,000	72
Total Cyanide	19	16	17	20	NS	NS
Amen. Cyanide	-430	-1700	-2,700	-1600	NS	NS
pH	10.4	11.2	10.6	11.1	NS	NS
Gross Alpha	<200 pCi/L	NA	<90 pCi/L	NA	NS	NS
Gross Beta	600±100 pCi/L	NA	00±100 pCi/L	NA	NS	NS

(1) Date when batch was mixed.
(2) TC Standard - Standards for metal compounds regulated by 40 CFR 261.24 for the characteristic of toxicity.
(3) LDR Standard - Standard for metal compounds regulated by 40 CFR 268 for F006, F007, and F009.

NS - No Standard
NA - Not Analyzed

TABLE 3-1F
POND 207C WATER AND SILT
LIME, CEMENT, AND FLYASH
TCLP (UG/L)

Analyte	Batch 19 4/3/92(1)		Batch 20 4/3/92(1)		Batch 21 4/3/92(1)		TC Standard(2)	LDR Standard(3)
	7 Day	28 Day	7 Day	28 Day	7 Day	28 Day		
Aluminum	2680	4880	3150	5130	3600	6260	NS	NS
Arsenic	70.0	103	<70.0	145	102	135	5,000	NS
Barium	624	456	596	457	612	442	100,000	NS
Cadmium	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	1,000	66
Calcium	1.75×10^6	1.78×10^6	1.65×10^6	1.7×10^6	1.64×10^6	1.69×10^6	NS	NS
Chromium	241	258	251	243	255	243	5,000	5,200
Iron	20.0	42.0	<20.0	<20.0	<20.0	<20.0	NS	NS
Lead	<30.0	<30.0	<30.0	33.0	<30.0	<30.0	5,000	510
Magnesium	170	213	159	170	159	184	NS	NS
Mercury	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	200	NS
Nickel	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0	NS	320
Selenium	<50.0	52.0	<50.0	<50.0	59	72.0	1,000	NS
Silver	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	5,000	72
Total Cyanide	18	15J	12	48J	14	21J	NS	NS
Amen. Cyanide	-1,400	R	-1,800	R	-5,000	R	NS	NS
pH	11.4	11.3	11.3	11.4	11.3	11.3	NS	NS
Gross Alpha	<200 pCi/L	NA	<200 pCi/L	NA	<200 pCi/L	NA	NS	NS
Gross Beta	560±110 pCi/L	NA	590±100 pCi/L	NA	570±110 pCi/L	NA	NS	NS

(1) Date when batch was mixed.
(2) TC Standard - Standards for metal compounds regulated by 40 CFR 261.24 for the characteristic of toxicity.
(3) LDR Standard - Standard for metal compounds regulated by 40 CFR 268 for F006, F007, and F009.

NS - No Standard
NA - Not Analyzed
J - Estimated
R - Rejected

TABLE 3-1G
POND 207C WATER AND SILT LIME, CEMENT, AND FLYASH
TCLP (UG/L)

Analyte	Batch 22 4/3/92(1)		Batch 23 4/3/92(1)		Batch 24 4/3/92(1)		TC Standard(2)	LDR Standard(3)
	7 Day	28 Day	7 Day	28 Day	7 Day	28 Day		
Aluminum	3060	5100	3220	4840	6070	8150	NS	NS
Arsenic	91.0	132	72.0	136	148	187	5,000	NS
Barium	694	445	502	417	524	416	100,000	NS
Cadmium	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	1,000	66
Calcium	1.72×10^6	1.75×10^6	1.64×10^6	1.7×10^6	1.54×10^6	1.57×10^6	NS	NS
Chromium	225	251	306	288	310	315	5,000	5,200
Iron	31.0	<20.0	<20.0	<20.0	23.0	<20.0	NS	NS
Lead	<30.0	<30.0	214	<30.0	66.0	<30.0	5,000	510
Magnesium	184	183	153	150	189	145	NS	NS
Mercury	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	200	NS
Nickel	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0	NS	320
Selenium	<50.0	<50.0	<50.0	57.0	<50.0	<50.0	1,000	NS
Silver	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	5,000	72
Total Cyanide	19	13J	13	110J	12	22(4)J	NS	NS
Amen. Cyanide	-2100	R	-3600	R	-610	R	NS	NS
pH	11.4	11.2	11.4	11.4	11.1	11.2	NS	NS
Gross Alpha	<200 pCi/L	NA	<200 pCi/L	NA	<200 pCi/L	NA	NS	NS
Gross Beta	600±100 pCi/L	NA	670±110 pCi/L	NA	770±120 pCi/L	NA	NS	NS

(1) Date when batch was mixed.
(2) TC Standard - Standards for metal compounds regulated by 40 CFR 261.24 for the characteristic of toxicity.
(3) LDR Standard - Standard for metal compounds regulated by 40 CFR 268 for F006, F007, and F009.
(4) This sample was analyzed as a matrix spike. Recovery of the spike was 70.1% which indicates the presence of a matrix interference. This should be considered when evaluating the data.

NS - No Standard
NA - Not Analyzed
J - Estimated
R - Rejected

TABLE 3-1H
POND 207C WATER AND SILT LIME, CEMENT, AND FLYASH
TCLP (UG/L)

Analyte	Batch 25 5/13/92(1)		Batch 26 5/13/92(1)		Batch 27 5/13/92(1)		TC Standard(2)	LDR Standard(3)
	7 Day	28 Day	7 Day	28 Day	7 Day	28 Day		
Aluminum	1800	3900	294	246	320	314	NS	NS
Arsenic	79.0	<80.0	116	97.0	118	<80.0	5,000	NS
Barium	570	440	1010	955	1280	1260	100,000	NS
Cadmium	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	1,000	66
Calcium	1.71×10^6	1.74×10^6	1.97×10^6	1.92×10^6	2.04×10^6	1.95×10^6	NS	NS
Chromium	173	178	74.0	58.0	79	100	5,000	5,200
Iron	39.0	<20.0	20.0	20.0	26.0	<20.0	NS	NS
Lead	<30.0	<30.0	<30.0	<30.0	<30.0	<30.0	5,000	510
Magnesium	116U	210	260	329	248	264	NS	NS
Mercury	<0.20	<0.20	<0.20	<20.0	<0.20	<20.0	200	NS
Nickel	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0	NS	320
Selenium	51.0	<70.0	62.0	<70.0	100	<70.0	1,000	NS
Silver	R	<5.0	R	<5.0	R	<5.0	5,000	72
Total Cyanide	38	<12.5	1200	1200	1100	1200	NS	NS
Amen. Cyanide	-3700	-170	-6900	-810	-6100	-2500	NS	NS
pH	11.6	11.3	11.5	11.4	11.6	11.4	NS	NS
Gross Alpha	<200 pCi/L	NA	<200 pCi/L	NA	<200 pCi/L	NA	NS	NS
Gross Beta	600±100 pCi/L	NA	670±110 pCi/L	NA	770±120 pCi/L	NA	NS	NS

(1) Date when batch was mixed.
(2) TC Standard - Standards for metal compounds regulated by 40 CFR 261.24 for the characteristic of toxicity.
(3) LDR Standard - Standard for metal compounds regulated by 40 CFR 268 for F006, F007, and F009.
NS - No Standard
NA - Not Analyzed
U - Not detected. Value represents elevated detection limit determined during data validation.
R - Rejected
NOTE: Data for 28-day cure not yet validated.

TABLE 3-11
POND 207C WATER AND SILT LIME, CEMENT, AND FLYASH
TCLP (UG/L)

Analyte	Batch 28 5/13/92(1)		Batch 29 5/13/92(1)		Batch 30 5/13/92(1)		TC Standard(2)	LDR Standard(3)
	7 Day	28 Day	7 Day	28 Day	7 Day	28 Day		
Aluminum	2440	4010	390	614	371	266	NS	NS
Arsenic	109	90.0	88.0	<80.0	99.0	102	5,000	NS
Barium	625J	440	1170J	867	1090	1106	100,000	NS
Cadmium	<5.0	<5.0	<5.0	5.0	<5.0	<5.0	1,000	66
Calcium	1.59×10^6	1.72×10^6	1.94×10^6	1.60×10^6	1.98×10^6	1.85×10^6	NS	NS
Chromium	202	195	85.0	36.0	71.0	61.0	5,000	5,200
Iron	49.0	<20.0	<20.0	<20.0	36.0	<20.0	NS	NS
Lead	<30.0	<30.0	<30.0	<30.0	<30.0	<30.0	5,000	510
Magnesium	131	170	233	232	223	272	NS	NS
Mercury	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	200	NS
Nickel	<20.0	<20.0	35.0	<20.0	<20.0	<20.0	NS	320
Selenium	55.0	<70.0	114	<70.0	129	<70.0	1,000	NS
Silver	R	<5.0	R	<5.0	R	<5.0	5,000	72
Total Cyanide	17	15	1000	360	1000	1100	NS	NS
Amen. Cyanide	-3700	-960	-1800	-1800	-3500	-480	NS	NS
pH	11.5	11.4	11.5	11.6	11.5	11.5	NS	NS
Gross Alpha	<200 pCi/L	NA	<200 pCi/L	NA	<200 pCi/L	NA	NS	NS
Gross Beta	600±100 pCi/L	NA	670±110 pCi/L	NA	770±120 pCi/L	NA	NS	NS

(1) Date when batch was mixed.
(2) TC Standard - Standards for metal compounds regulated by 40 CFR 261.24 for the characteristic of toxicity.
(3) LDR Standard - Standard for metal compounds regulated by 40 CFR 268 for F006, F007, and F009.
NS - No Standard
NA - Not Analyzed
J - Estimated
R - Rejected
NOTE: Data for 28 day cure not yet validated.

TABLE 3-2A
207C SLURRY AND CLARIFIER SLUDGE
LIME, CEMENT, AND FLYASH
TCLP (UG/L)

Analyte	Batch 1C 4/1/92(1)		Batch 2C 4/1/92(1)		Batch 3C 4/1/92(1)		TC Standard(2)	LDR Standard(3)
	7 Day	28 Day	7 Day	28 Day	7 Day	28 Day		
Aluminum	2,700	5460	3,380	5870	4,780	3590	NS	NS
Arsenic	84.0	90.0	<70.0	103	106	97.0	5,000	NS
Barium	603	531	740	509	847	741	100,000	NS
Cadmium	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	1,000	66
Calcium	1.68×10^6	1.73×10^6	1.54×10^6	1.63×10^6	1.5×10^6	1.39×10^6	NS	NS
Chromium	148	151	18.5	187	192	146	5,000	5,200
Iron	26.0	<20.0	<20.0	<20.0	21.0	<20.0	NS	NS
Lead	<30.0	<30.0	<30.0	<30.0	<30.0	<30.0	5,000	510
Magnesium	168	232	229	232	230	283	NS	NS
Mercury	0.2	<0.2	0.2	<0.2	<0.2	<0.2	200	NS
Nickel	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0	NS	320
Selenium	<50.0	<50.0	<50.0	<50.0	<50.0	<50.0	5,700	NS
Silver	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	5,000	72
Total Cyanide	20	24	22	24	33	47	NS	NS
Amen. Cyanide	-570	-160	-860	-120	-1,300	-140	NS	NS
pH	11.2	11.0	11.1	11.1	11.0	10.9	NS	NS
Gross Alpha	<200 pCi/L	NA	<200 pCi/L	NA	<200 pCi/L	NA	NS	NS
Gross Beta	280±90 pCi/L	NA	300±100 pCi/L	NA	350±100 pCi/L	NA	NS	NS

(1) Date when batch was mixed.
(2) TC Standard - Standards for metal compounds regulated by 40 CFR 261.24 for the characteristic of toxicity.
(3) LDR Standard - Standard for metal compounds regulated by 40 CFR 268 for F006, F007, and F009.

NS - No Standard
NA - Not Analyzed

TABLE 3-28
207C SLURRY AND CLARIFIER SLUDGE
LIME, CEMENT, AND FLYASH
TCLP (UG/L)

Analyte	Batch 4C 4/6/92(1)		Batch 5C 4/6/92(1)		Batch 6C 4/6/92(1)		Batch 7C 4/6/92(1)		Batch 8C 4/6/92(1)		TC Standard (2)	LDR Standard (3)
	7 Day	28 Day	7 Day	28 Day	7 Day	28 Day	7 Day	28 Day	7 Day	28 Day		
Aluminum	4520	3240	7440	6010	4320	4780	6610	4520	4670	5270	NS	NS
Arsenic	87.0	<70.0	<70.0	71.0	<70.0	116	<70.0	91.0	<70.0	96.0	5,000	NS
Barium	584	625	599	533	687	582	560	626	672	570	100,000	NS
Cadmium	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	1,000	66
Calcium	1.69×10^6	1.83×10^6	1.65×10^6	1.79×10^6	1.57×10^6	1.75×10^6	1.59×10^6	1.73×10^6	1.5×10^6	1.68×10^6	NS	NS
Chromium	223	227	209	213	201	225	214	252	198	219	5,000	5,200
Iron	27.0U	<20.0	45.0U	<20.0	<20.0	<20.0	<20.0	102	<20.0	<20.0	NS	NS
Lead	<30.0	<30.0	<30.0	<30.0	<30.0	<30.0	<30.0	<30.0	<30.0	<30.0	5,000	510
Magnesium	233	125	207U	145	181U	164	163U	142	198U	157	NS	NS
Mercury	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	200	NS
Nickel	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0	NS	320
Selenium	<50.0	<50.0	<50.0	<50.0	60.0	<50.0	<50.0	<50.0	<50.0	<50.0	1,000	NS
Silver	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	5,000	72
Total Cyanide	12	32	13	17	13	12	13	20	16	31	NS	NS
Amen. Cyanide	-140	-940	-1,100	-2000	-370	-3200	-2,300	-1800	-1,300	-1500	NS	NS
pH	11.2	11.3	11.0	11.2	11.0	11.1	11.0	11.2	11.0	11.1	NS	NS
Gross Alpha	<200 pCi/L	NA	<200 pCi/L	NA	<200 pCi/L	NA	<200 pCi/L	NA	<200 pCi/L	NA	NS	NS
Gross Beta	420±100 pCi/L	NA	670±100 pCi/L	NA	580±100 pCi/L	NA	600±110 pCi/L	NA	740±110 pCi/L	NA	NS	NS

(1) Date when batch was mixed.
(2) TC Standard - Standards for metal compounds regulated by 40 CFR 261.24 for the characteristic of toxicity.
(3) LDR Standard - Standard for metal compounds regulated by 40 CFR 268 for F006, F007, and F009.

NS - No Standard
U - Not Detected. Value represents elevated detection limit determined during data validation.

TABLE 3-2C
207C SLURRY AND CLARIFIER SLUDGE
LIME AND CEMENT
TCLP (UG/L)

Analyte	Batch 9C 4/6/92(1)(2)		Batch 10C 4/6/92(1)		Batch 11C 4/6/92(1)		Batch 12C 4/6/92(1)		Batch 13C 4/6/92(1)		Batch 14C 4/6/92(1)		TC Standard (3)	LDR Standard (4)
	7 Day	28 Day	7 Day	28 Day	7 Day	28 Day	7 Day	28 Day	7 Day	28 Day	7 Day	28 Day		
Aluminum	1500	968	59.0U	25.0	47.0U	<20.0	39U	<20.0	47.0U	<20.0	27.0U	<20.0	NS	NS
Arsenic	<70.0	<70.0	<70.0	<70.0	<70.0	99.0	71.0	80.0	<70.0	113	<70.0	120	5,000	NS
Barium	742	1810J	1180	2200	1240	1990	994	1500	922	1100U	751	916	100,000	NS
Cadmium	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<0.5	<5.0	<5.0	<5.0	<5.0	1,000	66
Calcium	21.5×10^6	1.61×10^6	2.01×10^6	2.11×10^6	1.9×10^6	2.13×10^6	1.89×10^6	2.19×10^6	1.94×10^6	2.15×10^6	1.93×10^6	2.16×10^6	NS	NS
Chromium	204	166	175	142	207	125	236	197	253	214	313	256	5,000	5,200
Iron	27.0U	<20.0	88.0U	29.0	25.0U	<20.0	<20.0	<20.0	20.0	<20.0	20.0	<20.0	NS	NS
Lead	<30.0	<30.0	<30.0	<30.0	<30.0	<30.0	<30.0	<30.0	<30.0	<30.0	<30.0	<30.0	5,000	510
Magnesium	152U	67.0	113U	40.0	111U	41.0	84.0U	49.0	103U	48.0	105U	41.0	NS	NS
Mercury	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	200	NS
Nickel	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0	NS	320
Selenium	<50.0	<50.0	<50.0	<50.0	<50.0	<50.0	<50.0	<50.0	<50.0	<50.0	<50.0	<20.0	1,000	NS
Silver	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	5,000	72
Total Cyanide	15	24	17	18	15	26	16	23	20	25	20	22	NS	NS
Amen. Cyanide	-1600	-1500	-110	-3100	-2,100	-1100	-1,600	-1400	-1,800	-3500	-2,600	-700	NS	NS
pH	11.5	11.6	12.1	12.1	12.1	12.1	12.1	12.21	12.1	12.2	12.1	12.1	NS	NS
Gross Alpha	<200 pCi/L	NA	<200 pCi/l	NA	<200 pCi/L	NA	<200 pCi/L	NA	<200 pCi/L	NA	<200 pCi/L	NA	NS	NS
Gross Beta	780±110 pCi/L	NA	430±100 pCi/L	NA	490±100 pCi/L	NA	560±110 pCi/L	NA	620±110 pCi/L	NA	740±110 pCi/L	NA	NS	NS

(1) Date when batch was mixed.
(2) Batch 9C has a cement to flyash ratio of 1 to 1.
(3) TC Standard - Standard for metal compounds regulated by 40 CFR 261.24 for the characteristic of toxicity.
(4) LDR Standard - Standard for metal compounds regulated by 40 CFR 268 for F006, F007, and F009.

NS - No Standard
NA - Not Analyzed
U - Not Detected. Value represents elevated detection limit determined during data validation.
J - Estimated Value.

TABLE 3-2D
POND 207C SLURRY AND CLARIFIER SLUDGE
LIME, CEMENT, AND FLYASH
TCLP (UG/L)

Analyte	Batch 15C 5/13/92(1)		Batch 16C 5/13/92(1)		Batch 17C 5/13/92(1)		TC Standard(2)	LDR Standard(3)
	7 Day	28 Day	7 Day	28 Day	7 Day	28 Day		
Aluminum	3680	7230	165U	306	252	536	NS	NS
Arsenic	<70.0	<80.0	110	<80.0	70.0	<80.0	5,000	NS
Barium	637	423	752	886	760	817	100,000	NS
Cadmium	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	1,000	66
Calcium	1.79×10^6	1.80×10^6	1.93×10^6	1.69×10^6	2.0×10^6	1.75×10^6	NS	NS
Chromium	188	194	95.0	40.0	99.0	50.0	5,000	5,200
Iron	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0	NS	NS
Lead	<30.0	<30.0	<30.0	<30.0	<30.0	<30.0	5,000	510
Magnesium	181	302	284	279	364	295	NS	NS
Mercury	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	200	NS
Nickel	<20.0	<20.0	40.0	<20.0	24.0	<20.0	NS	320
Selenium	64.0	<70.0	<50.0	<70.0	87.0	<70.0	1,000	NS
Silver	R	<5.0	R	<5.0	R	<5.0	5,000	72
Total Cyanide	28	24	82	43	1100	62	NS	NS
Amen. Cyanide	-1300	-1000	-2400	-1500	-2700	-1700	NS	NS
pH	11.3	11.1	11.4	11.5	11.3	11.4	NS	NS
Gross Alpha	<200 pCi/L	NA	<200 pCi/L	NA	<200 pCi/L	NA	NS	NS
Gross Beta	600±100 pCi/L	NA	670±110 pCi/L	NA	770±120 pCi/L	NA	NS	NS

TABLE 3-2D
POND 207C WATER AND SILT LIME, CEMENT, AND FLYASH
TCLP (UG/L)
PAGE TWO

(1) Date when batch was mixed.
(2) TC Standard - Standards for metal compounds regulated by 40 CFR 261.24 for the characteristic of toxicity.
(3) LDR Standard - Standard for metal compounds regulated by 40 CFR 268 for F006, F007, and F009.

NS - No Standard
NA - Not Analyzed
U - Not detected. Value represents elevated detection limit determined during data validation.
R - Rejected

NOTE: Data for 28-day cure not yet validated.

TABLE 3-3A
POND 207C WATER AND SILT
LIME, CEMENT, FLYASH, AND LATEX 2000
TCLP (UG/L)

Analyte	Batch 1L 2/13/92(1)		Batch 2L 2/13/92(1)		Batch 3L 2/13/92(1)		Batch 4L 2/13/92(1)		Batch 5L 2/13/92(1)		Batch 6L 2/13/92(1)		Batch 7L 2/13/92(1)		Batch 8L 2/13/92(1)		Batch 9L 2/13/92(1)		TC Standard (2)	LDR Standard (3)
	7 Day	28 Day	7 Day	28 Day	7 Day	28 Day	7 Day	28 Day	7 Day	28 Day	7 Day	28 Day	7 Day	28 Day	7 Day	28 Day	7 Day	28 Day		
Aluminum	NA	16700	NA	2030	NA	6320	NA	2930	NA	5340	NA	13300	NA	5020	NA	6350	NA	2740	NS	NS
Arsenic	100	<70	<70	81	110	147	<70	89	<70	88	70	153	<70	116	100	160	<70	101	5,000	NS
Barium	740	568	780	536	580	425	810	514	630	422	630	630	580	469	590	423	790	469	100,000	NS
Cadmium	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	1,000	66
Calcium	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NS	NS
Chromium	280	281	330	295	380	319	300	282	290	270	270	242	250	244	300	273	260	258	5,000	5,200
Iron	NA	20	NA	<20	NA	25	NA	<20	NA	100	NA	119	NA	67	NA	<20	NA	22	NS	NS
Lead	<30.0	<30	<30	<30	<30	<30	<30	<30	<30	<30	<30	<30	<30	<30	<30	<30	<30	<30	5,000	510
Magnesium	NA	272	NA	120	NA	170	NA	143	NA	194	NA	316	NA	265	NA	179	NA	136	NS	NS
Mercury	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	200	NS
Nickel	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	NS	320
Selenium	<50	<50	<50	<50	<50	<50	<50	<50	<50	61	<50	<50	<50	<50	<50	<50	<50	<50	1,000	NS
Silver	<5.0	<5.0UJ	<5.0	<5.0UJ	<5.0	<5.0UJ	<5.0	<5.0UJ	<5.0	<5.0UJ	<5.0	<5.0UJ	<5.0	<5.0UJ	<5.0	<5.0UJ	<5.0	<5.0UJ	5,000	72
Total Cyanide	NA	<12	NA	15	NA	13	NA	14	NA	17	NA	14	NA	16	NA	17	NA	16	NS	NS
Amen. Cyanide	NA	-760	NA	-100	NA	-390	NA	-650	NA	-130	NA	-1,500	NA	-78	NA	-140	NA	-220	NS	NS
pH	11.1	11.0	11.7	11.7	11.4	11.4	11.6	11.6	11.4	11.3	11.2	11.0	11.4	11.3	11.4	11.3	11.7	11.6	NS	NS

(1) Date when batch was mixed.
(2) TC Standard - Standards for metal compounds regulated by 40 CFR 261.24 for the characteristic of toxicity.
(3) LDR Standard - Standard for metal compounds regulated by 40 CFR 268 for F006, F007, and F009.

NS - No Standard
NA - Not Analyzed
UJ - Estimated Non detect

TABLE 3-38
207C WATER AND SILT
LIME, CEMENT, FLYASH, AND LATEX 2000
TCLP (UG/L)

Analyte	Batch 10L 4/2/92(1)		Batch 11L 4/2/92(1)		Batch 12L 4/2/92(1)		Batch 13L 4/2/92(1)		Batch 14L 4/2/92(1)		TC Standard (2)	LDR Standard (3)
	7 Day	28 Day	7 Day	28 Day	7 Day	28 Day	7 Day	28 Day	7 Day	28 Day		
Aluminum	2740	6740	2980	6430	1150	3620	1690	4330	2490	4250	NS	NS
Arsenic	101	110	84.0	129	<70.0	106	<70.0	<70.0	93.0	97.0	5,000	NS
Barium	673	502	666	596	1070	605	738	590	629	617	100,000	NS
Cadmium	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	1,000	66
Calcium	1.60×10^6	1.67×10^6	1.63×10^6	1.65×10^6	1.69×10^6J	1.83×10^6	1.69×10^6	1.85×10^6	1.7×10^6	1.75×10^6	NS	NS
Chromium	165	148	149	153	97.0	130	131	143	147	134	5,000	5,200
Iron	<20.0	35.0	<20.0	24.0	<20.0	24.0	<20.0	<20.0	<20.0	<20.0	NS	NS
Lead	<30.0	<30.0	<30.0	<30.0	<30.0	<30.0	<30.0	<30.0	<30.0	<30.0	5,000	510
Magnesium	171	163	158	171	162	198	167	188	174	174	NS	NS
Mercury	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	200	NS
Nickel	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0	NS	320
Selenium	<50.0	52.0	<50.0	60.0	<50.0	<50.0	<50.0	<50.0	<50.0	<50.0	5,700	NS
Silver	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	5,000	72
Total Cyanide	26	14	15	12	<12	13	20	12	14	13	NS	NS
Amen. Cyanide	-2,200	-1800	-1,700	-1600	-1600	-4300	-1,400	-1200	-1,100	-5500	NS	NS
pH	10.8	11.0	10.4	11.0	10.8	11.3	10.6	11.2	10.7	11.2	NS	NS
Gross Alpha	<200 pCi/L	NA	<200 pCi/L	NA	200 pCi/L	NA	200 pCi/L	NA	200 pCi/L	NA	NS	NS
Gross Beta	670±100 pCi/L	NA	670±100 pCi/L	NA	410±100 pCi/L	NA	480±100 pCi/L	NA	500±100 pCi/L	NA	NS	NS

(1) Date when batch was mixed.
(2) TC Standard - Standards for metal compounds regulated by 40 CFR 261.24 for the characteristic of toxicity.
(3) LDR Standard - Standard for metal compounds regulated by 40 CFR 268 for F006, F007, and F009.

NS - No Standard
NA - Not Analyzed
J - Estimated Value

TABLE 3-3C
207C WATER AND SILT
LIME, CEMENT, FLYASH, AND LATEX 2000
TCLP (UG/L)

Analyte	Batch 15L 4/3/92(1)		Batch 16L 4/3/92(1)		Batch 17L 4/3/92(1)		Batch 18L 4/3/92(1)		Batch 19L 4/3/92(1)		TC Standard (2)	LDR Standard (3)
	7 Day	28 Day	7 Day	28 Day	7 Day	28 Day	7 Day	28 Day	7 Day	28 Day		
Aluminum	2760	4660	2230	3020	2680	3930	4030	5580	2890	3050	NS	NS
Arsenic	75.0	83.0	104	127	85	107	93.0	152	91.0	104	5,000	NS
Barium	653	554	744	609	623	521	514	447	618	486	100,000	NS
Cadmium	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	1,000	66
Calcium	1.78×10^6	1.73×10^6	1.76×10^6	8.93×10^6	1.67×10^6J	1.8×10^6	1.51×10^6	1.65×10^6	1.73×10^6	1.78×10^6	NS	NS
Chromium	254	258	229	234	262	259	328	330	266	267	5,000	5,200
Iron	<20.0	23.0	<20.0	<20.0	31.0	26.0	<20.0	<20.0	26.0	<20.0	NS	NS
Lead	<30.0	<30.0	<30.0	<30.0	<30.0	<30.0	<30.0	<30.0	<30.0	<30.0	5,000	510
Magnesium	163	179	166	262	156	171	158	164	170	187	NS	NS
Mercury	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	200	NS
Nickel	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0	NS	320
Selenium	<50.0	<50.0	<50.0	51.0	<50.0	<50.0	<50.0	<50.0	<50.0	95.0	1,000	NS
Silver	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	5,000	72
Total Cyanide	17	17J	14	19J	19	20J	26	22J	25	14J	NS	NS
Amen. Cyanide	-3,000	R	-3,300	R	-2,500	R	-3,400	R	-1,700	R	NS	NS
pH	11.4	11.4	11.4	11.3	11.4	11.4	11.3	11.3	11.4	11.4	NS	NS
Gross Alpha	<200 pCi/L	NA	<200 pCi/L	NA	<200 pCi/L	NA	<200 pCi/L	NA	<300 pCi/L	NA	NS	NS
Gross Beta	480±100 pCi/L	NA	540±110 pCi/L	NA	670±110 pCi/L	NA	810±270 pCi/L	NA	600±110 pCi/L	NA	NS	NS

(1) Date when batch was mixed.
(2) TC Standard - Standards for metal compounds regulated by 40 CFR 261.24 for the characteristic of toxicity.
(3) LDR Standard - Standard for metal compounds regulated by 40 CFR 268 for F006, F007, and F009.
NS - No Standard
NA - Not Analyzed
J - Estimated Value
R - Rejected

TABLE 3-4
207C SLURRY AND CLARIFIER SLUDGE
LIME, CEMENT, FLYASH, AND LATEX 2000
TCLP (UG/L)

Analyte	Batch 1CL 4/6/92(1)		Batch 2CL 4/6/92(1)		Batch 3CL 4/6/92(1)		Batch 4CL 4/6/92(1)		Batch 5CL 4/6/92(1)		TC Standard (2)	LDR Standard (3)
	7 Day	28 Day	7 Day	28 Day	7 Day	28 Day	7 Day	28 Day	7 Day	28 Day		
Aluminum	4040	4750	6040	4880	4800	5860	5530	4870	7320	6540	NS	NS
Arsenic	<70.0	93.0	<70.0	86.0	74.0	82.0	<70.0	92.0	<70.0	72.0	5,000	NS
Barium	545	546	612	684	606	<5.0	591	570	511	527	100,000	NS
Cadmium	<5.0	<5.0	<5.0	<5.0	<5.0	1.78×10^6	<5.0	<5.0	<5.0	<5.0	1,000	66
Calcium	1.72×10^6	1.8×10^6	1.66×10^6	1.58×10^6	1.74×10^6	225	1.56×10^6	1.87×10^6	1.61×10^6	1.76×10^6	NS	NS
Chromium	203	209	209	211	185	<20.0	208	228	211	231	5,000	5,200
Iron	<20.0	<20.0	82.0U	<20.0	67.0U	<30.0	<20.0	121	<20.0	<20.0	NS	NS
Lead	<30.0	<30.0	<30.0	<30.0	<30.0	138	<30.0	<30.0	<30.0	<30.0	5,000	510
Magnesium	194U	147	212U	174	218U	<0.2	235	139	133U	135	NS	NS
Mercury	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	200	NS
Nickel	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0	NS	320
Selenium	<50.0	<50.0	<50.0	<50.0	<50.0	<50.0	<50.0	<800(E)	<50.0	<50.0	1,000	NS
Silver	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	5,000	72
Total Cyanide	15	14	15	16	19	16	20	16	14	25	NS	NS
Amen. Cyanide	-1,300	-580	-1,300	-210	-1,500	-170	-2,100	-200	-2,000	-160	NS	NS
pH	11.1	11.2	11.0	11.0	11.1	11.2	11.0	11.2	11.2	11.1	NS	NS
Gross Alpha	<90 pCi/L	NA	<200 pCi/L	NA	<200 pCi/L	NA	<200 pCi/L	NA	<200 pCi/L	NA	NS	NS
Gross Beta	610±100 pCi/L	NA	650±110 pCi/L	NA	530±110 pCi/L	NA	610±110 pCi/L	NA	690±120 pCi/L	NA	NS	NS

(1) Date when batch was mixed.
(2) TC Standard - Standards for metal compounds regulated by 40 CFR 261.24 for the characteristic of toxicity.
(3) LDR Standard - Standard for metal compounds regulated by 40 CFR 268 for F006, F007, and F009.

NS - No Standard
NA - Not Analyzed
U - Not Detected. Value represents elevated detection limit determined during data validation.

standard for F006, F007, and F009 wastes. The standard is 510 ug/l. The data for Batch 15 after 28 days of curing is below the detection limit (<30 ug/l). There is no apparent reason why this one data point is above the LDR standard.

There is no significant difference in the analytical data for those batches with Pond 207C vs. the batches with Pond 207C combined with the Clarifier sludge. Additionally, the use of the Latex 2000 System had no adverse effect on the TCLP results. The pH of the TCLP extracts ranged from 10.4 to 12.1. The pH of the TCLP extract is an important parameter with regards to metal leachability. The results of the TCLP leachate analysis throughout the treatability study have passed all RCRA criteria when the pH of the leachate ranged from 9.0 to 12.3. Even when the pH of the leachate falls below 9.0, the extract can still pass the RCRA criteria. However, the metal concentrations in the leachate will begin to increase and approach their respective limits (further discussion is provided in Section 3.1.1.2).

Total cyanide was detected in 45 of 50 TCLP leachate samples analyzed. The total cyanide concentration in the TCLP leachate ranged from less than 12 μg/l to 33 μg/l. The data for amenable cyanide indicates that most of the values are reported as negatives. Amenable cyanide concentrations are typically reported as negative vs. less than zero when cyanide is complexed with metals. Cyanide concentration data in TCLP leachates are not required for waste certification. The data was gathered to assess the effectiveness of the CSS systems tested and to determine the leaching potential of cyanide. Although there is no LDR (CCWE) standard for cyanide in the TCLP leachate, all values are less than the Maximum Contaminant Limit (MCL) for cyanide (50 ug/l) in drinking waters.

The values for gross alpha in the TCLP leachate are consistently reported as less than 200 pCi/l. Gross beta results range from 280 +/- 100 pCi/l to 780 +/- 110 pCi/l. These values indicate that TCLP leachates can be shipped off-site for analysis via air transportation during remediation, if required. However, review of the radionuclide data indicates that the entire test cylinder can also be shipped off-site for analysis. The current plan is to ship cured test cylinders to the Pittsburgh Laboratory for analysis. Additional details are provided in Attachment E.

3.1.1.2 TCLP Metal Sensitivity to pH

One of the most important factors controlling the TCLP extract concentration of heavy metals is the pH of the extraction fluid. The lime/cement/flyash CSS system adds considerable amounts of alkalinity to the waste (by the addition of hydroxide from the lime and the creation of hydroxide during the cement hydration reaction), resulting in the TCLP extract having a pH in the range of 10-12. Many, but not all, metal hydroxides are less soluble at higher pHs than at lower pHs.

The mixes tested during the regulatory confirmation phase of testing successfully passed all LDR and RCRA hazardous toxicity criteria, with the exception of one 7-day cure value for lead in Batch 15 (see discussion in Section 3.1.1.1). However, because the pH of the TCLP extracts in this phase were consistently in the pH 10.4-12.1 range, and the metals concentrations showed little variation at these pH values, the data from this phase are not useful for determining the dependence of extract metals concentration on extract pH. To accomplish this, data gathered during Phases I/II must be used. These data, which are presented in Attachment A, include a much wider range of TCLP extract pH values. For the lime/cement/flyash batches tested, the extract pH ranged from 6.9 to 12.1 (see Section 2.0 of the report included in Attachment A-2). For the lime/cement/flyash/Latex 2000 batches tested, the extract pH ranged from 9.6 to 11.0 (see Section 5.0 of the report included in Attachment A-2). These data serve as a baseline to which Phase III/IV data can be compared.

A series of graphs have been prepared in which TCLP metals concentrations are plotted against TCLP extract pH. The plots are provided in Attachment F and are described as follows:

- Group I, Figures 1 through 9: data for 207C plus lime/cement/flyash
- Group II, Figure 10 through 18: data for 207C plus lime/cement/flyash/Latex 2000
- Group III, Figures 19 through 27: data for 207C/clarifier plus lime/cement/flyash
- Group IV, Figures 28 through 36: data for 207C/clarifier plus lime/cement/flyash/Latex 2000

Both 7-day cure and 28-day cure TCLP data from Phase III/IV testing are included on the figures.

Following is an assessment of each metal of regulatory concern:

- Arsenic - Both baselines (lime/cement/flyash mixed with and without latex) for TCLP arsenic concentrations show no dependency on TCLP extract pH. Both baselines are an order of magnitude below the toxicity characteristic (TC) standard of 5 mg/l. As predicted by the baselines, the Phase III/IV data are at or below the baseline at the high pH range. Arsenic shows little potential for leaching above the TC standard, even if the pH of the extract falls into the 7-10 range.

- Barium - The baselines for TCLP barium concentrations are well below the TC standard of 100 mg/l and show little or no dependency on pH in the range tested. All phase III/IV data are at or near the baseline at the pH 10-12 range tested. Barium shows little potential for leaching above the TC standard at the pH range tested.

- Cadmium - The baseline for cadmium vs. pH for the lime/cement/flyash mixes shows a clear trend of decreasing cadmium concentrations with increasing pH. The limited Phase I/II data seem to indicate that if the TCLP extract pH falls below 6 (approximate), then the LDR standard of 0.066 mg/l might be exceeded. Conversely, at pH values greater than 9, the TCLP extract cadmium concentration decreases to concentrations with a reasonable safety factor. The Phase III/IV data, in the pH 10-12 range, verify this. The cadmium data for the latex tests show no dependence on pH.

- Chromium - Both baselines for TCLP chromium show little dependence on TCLP extract pH in the range tested. Phase III/IV data follows the trend of the baseline at the pH 10-12 range tested. Chromium shows little potential for leaching above the TC standard of 5 mg/l.

- Lead - Both baselines for TCLP lead concentrations show little dependency on TCLP extract pH. The only non-passing LDR criteria point was Batch 15 (4/2/92) at a pH of 10.5 after a seven day cure. It appears that there may be a higher possibility of exceeding the LDR standard in the pH range of 10.5 to 11.5 where five additional points approached the 0.5 mg/l LDR standard cut-off line. Lead shows very little potential for leaching in the pH 7-10 range, and upon full 28-day cure, lead shows little potential for leaching in the full range of pH tested.

- Mercury - Both baselines (for lime/cement/flyash mixes with and without Latex) for TCLP mercury concentrations show no dependency on TCLP extract pH. Both lines are an order of magnitude below the toxicity characteristic (TC) standard of 0.2 mg/l. The Phase III/IV data are well within the acceptable range at all pH readings. Mercury shows very little potential for leaching in the full pH range tested.

- Selenium - The baseline for the TCLP concentrations are well below the TC standard of 1 mg/l and show little or no dependency on pH in the testing range for the Phase III/IV. The selenium data for the lower pH range of 9.5-10.5 for the Phase I/II testing show a slight trend in the Latex baseline, but the data are well below the TC standard.

- Silver - The baseline for silver vs. pH for the lime/cement/flyash mixes shows a clear trend of decreasing silver concentrations with increasing pH. The slope of the curve provided by the Phase I/II data seems to indicate that silver concentrations will remain within the LDR and TC standards, even at lower pHs (<6). The baseline for all testing for the lime/cement/flyash/Latex mixes and the Phase III/IV data for the lime/cement/flyash mixes are an order of magnitude below the LDR standard. Silver shows little potential for leaching above the LDR standard.

- Nickel - The baseline for nickel vs. pH for the lime/cement/flyash mixes shows a very pronounced trend of decreasing nickel concentrations with increasing pH. The limited Phase I/II data seem to indicate that if the TCLP extract pH falls below approximately 6.5, then the LDR standard of 0.32 mg/l might be exceeded. Conversely, at pH values greater than 9.5, the TCLP extract nickel concentrations decreases to concentrations with a reasonable safety factor. The Phase III/IV data, in the pH 11-12 range, verify this. Nickel shows little potential for leaching above the LDR standard in a pH range above 10. The nickel data for the Latex tests show no dependency on pH, and nickel has very little potential for leaching above the LDR standard for all pH levels tested.

3.1.1.3 TCLP Volatile Organic Results

As previously mentioned in Section 2.3.3, characterization data for Pond 207C slurry and clarifier indicate the presence of several volatile organics at relatively low concentrations. However, none are present in concentrations to be of regulatory concern (exceeding LDR standards in the TCLP ZHE concentration or exceeding the toxicity characteristic in the TCLP ZHE extract for classification as a characteristic hazardous waste). As a confirmation, the centerpoint mixes (water to pozzolan ratios of 0.42) were subjected to the TCLP ZHE, and the extract analyzed for volatile organics.

Concentrations of volatile organics in the TCLP leachate are shown in Table 3-5 for the batches prepared with Pond 207C water and silt. Table 3-6 provides the results for the batches prepared with Pond 207C slurry and the Clarifier. Tables 3-5 and 3-6 represent batches that were prepared using lime, cement, and flyash as the CSS binder. Tables 3-7 and 3-8 provide the data for the batches prepared with Pond 207C water and silt and Pond 207C slurry with the Clarifier, respectively. Tables 3-7 and 3-8 represent the mixes prepared with lime, cement, flyash, and Latex 2000 as the CSS binder. Also shown are the regulatory standards for the LDR criteria (40 CFR 268) and the standards for the toxicity characteristic (40 CFR 261.24).

The results for the TCLP zero-headspace extraction (ZHE) analyses indicate that all samples are at concentrations below the LDR criteria. All of the data reported as non-detects.

3.1.1.4 Free Liquid Requirements

A requirement for waste shipment and waste acceptance at NTS is no free liquid in the final waste form. The Paint Filter Liquids Test described in Section 2.3.3, is used to determine the presence or absence of free liquid. The liquid/solids test is a Department of Transportation test to determine if the material is a solid or a liquid with regard to packaging requirements.

Tables 3-9 and 3-10 provide the results of the free liquid tests for the batches mixed with Pond 207C slurry, and the batches mixed with Pond 207C slurry and the clarifier sludge, respectively. These batches were prepared with lime, cement,

TABLE 3-5
207C WATER AND SILT MIX
LIME/CEMENT/FLYASH
28-DAY CURE
TCLP VOLATILES
(UG/L)

Analyte	Batch 2 2/13/92(1)	Batch 7 4/6/92(1)	Batch 10 4/3/92 (1)	Batch 14 4/2/92(1)	Batch 17 4/2/92(1)	Batch 20 4/3/92(1)	Batch 23 4/3/92(1)	LDR Standard(2)	TC Standard(3)
Benzene	<50	<50	<50	<50	<50	<50	<50	NS	500
2-butanone	<100	<100	<100	<100	<100	<100	<100	750	200,000
Carbon Tetrachloride	<50	<50	<50	<50	<50	<50	<50	960	500
Chlorobenzene	<50	<50	<50	<50	<50	<50	<50	50	100,000
Chloroform	<50	<50	<50	<50	<50	<50	<50	NS	6,000
1,2-dichloroethane	<50	<50	<50	<50	<50	<50	<50	NS	500
1,1-dichloroethene	<50	<50	<50	<50	<50	<50	<50	NS	700
Tetrachloroethylene	<50	<50	<50	<50	<50	<50	<50	50	700
Trichloroethylene	<50	<50	<50	<50	<50	<50	<50	91	500
Vinyl Chloride	<100	<100	<100	<100	<100	<100	<100	NS	200

(1) Date when batch was mixed.
(2) LDR Standard - These values represent the standards for the compounds analyzed as regulated by 40 CFR 268 for listed wastes F001, F002, F003, and F005.
(3) TC Standard - These values represent the standards for volatile organics which are regulated by 40 CFR 261.24 (Characteristic Hazardous Waste by the Characteristic of Toxicity).

NS - No RCRA Standard.

TABLE 3-6
207C SLURRY AND CLARIFIER MIX
LIME/CEMENT/FLYASH
28-DAY CURE
TCLP VOLATILES
(ug/l)

Analyte	Batch 2C 4/1/92(1)	Batch 6C 4/6/92(1)	Batch 12C 4/6/92(1)	LDR Standard(2)	TC Standard(3)
Benzene	<50	<50	<50	NS	500
2-butanone	<100	<100	<100	750	200,000
Carbon Tetrachloride	<50	<50	<50	960	500
Chlorobenzene	<50	<50	<50	50	100,000
Chloroform	<50	<50	<50	NS	6,000
1,2-dechloroethane	<50	<50	<50	NS	500
1,1-dichloroethene	<50	<50	<50	NS	700
Tetrachloroethylene	<50	<50	<50	50	700
Trichlorethylene	<50	<50	<50	91	500
Vinyl Chloride	<100	<100	<100	NS	200

(1) Date when batch was mixed.
(2) LDR Standard - These values represent the standards for the compounds analyzed as regulated by 40 CFR 268 for listed wastes F001, F002, F003, and F005.
(3) TC Standard - These values represent the standards for volatile organics which are regulated by 40 CFR 261.24 (Characteristic Hazardous Waste by the Characteristic of Toxicity).

NS - No RCRA Standard.

TABLE 3-7
207C WATER AND SILT MIX
LIME/CEMENT/FLYASH/LATEX
28-DAY CURE
TCLP VOLATILES
(ug/l)

Analyte	Batch 1L 2/13/92(1)	Batch 14L 4/2/92(1)	Batch 17L 4/2/92(1)	LDR Standard (2)	TC Standard (3)
Benzene	<50	<50	<50	NS	500
2-butanone	<100	<100	<100	750	200,000
Carbon Tetrachloride	<50	<50	<50	960	500
Chlorobenzene	<50	<50	<50	50	100,000
Chloroform	<50	<50	<50	NS	6,000
1,2-dechloroethane	<50	<50	<50	NS	500
1,1-dichloroethene	<50	<50	<50	NS	700
Tetrachloroethylene	<50	<50	<50	50	700
Trichlorethylene	<50	<50	<50	91	500
Vinyl Chloride	<100	<100	<100	NS	200

(1) Date when batch was mixed.
(2) LDR Standard - These values represent the standards for the compounds analyzed as regulated by 40 CFR 268 for listed wastes F001, F002, F003, and F005.
(3) TC Standard - These values represent the standards for volatile organics which are regulated by 40 CFR 261.24 (Characteristic Hazardous Waste by the Characteristic of Toxicity).

NS - No RCRA Standard.

TABLE 3-8
207C SLURRY AND CLARIFIER MIX
LIME/CEMENT/FLYASH/LATEX
28-DAY CURE
TCLP VOLATILES
(ug/l)

Analyte	Batch 3CL 4/6/92(1)	LDR Standard (2)	TC Standard(3)
Benzene	<50	NS	500
2-butanone	<100	750	200,000
Carbon Tetrachloride	<50	960	500
Chlorobenzene	<50	50	100,000
Chloroform	<50	NS	6,000
1,2-dichloroethane	<50	NS	500
1,1-dichloroethene	<50	NS	700
Tetrachloroethylene	<50	50	700
Trichloroethylene	<50	91	500
Vinyl Chloride	<100	NS	200

(1) Date when batch was mixed.
(2) LDR Standard - These values represent the standards for the compounds analyzed as regulated by 40 CFR 268 for listed wastes F001, F002, F003, and F005.
(3) TC Standard - These values represent the standards for volatile organics which are regulated by 40 CFR 261.24 (Characteristic Hazardous Waste by the Characteristic of Toxicity).

NA - No RCRA Standard.

TABLE 3-9
207C WATER AND SILT MIXES
LIME, CEMENT, AND FLYASH
FREE LIQUID TEST CRITERIA

Batch	Date Mixed	Paint Filter Liquid Test(1)		Liquid/Solids Test(2)	
		Pass	Fail	Pass	Fail
1	2/13/92	X		NT	NT
2	2/13/92	X		NT	NT
3	2/13/92	X		NT	NT
4	2/13/92	X		NT	NT
5	2/13/92	X		NT	NT
6	4/6/92	X		X	
7	4/6/92	X		X	
8	4/6/92	X		X	
9	4/3/92	X		X	
10	4/3/92	X		X	
11	4/3/92	X		X	
12	4/2/92	X		X	
13	4/2/92	X		X	
14	4/2/92	X		X	
15	4/2/92	X		X	
16	4/2/92	X		X	
17	4/2/92	X		X	
18	4/2/92	X		X	
19	4/3/92	X		X	
20	4/3/92	X		X	
21	4/3/92	X		X	
22	4/3/92	X		X	
23	4/3/92	X		X	
24	4/3/92	X		X	
25	(5/13/92)(3)	X		X	
26	(5/13/92)(4)		X (9)		X(10)
27	(5/13/92)(5)		X (10)		X (10)
28	(5/13/92)(6)	X		X	
29	(5/13/92)(7)		X (13)		X (11)
30	(5/13/92)(8)		X (11)		X (12)

TABLE 3-9
207C WATER AND SILT MIXES
LIME, CEMENT, AND FLYASH
FREE LIQUID TEST CRITERIA
PAGE TWO

(1) Paint Filter Liquids Test - SW 846, Method 9095
(2) ASTM D4359-84 - Standard Test Method for Determining Whether a material is a Liquid or a Solid.
(3) Additive Mixture: Added D-Air-2 at 0.25% of total pozzolan weight.
(4) Additive Mixture: Added superplasticizer at 1.67% by weight of pozzolans.
(5) Additive Mixture: Added D-Air-2 at 0.25% and superplasticizer at 1.67% by weight of pozzolans.
(6) Additive Mixture: Added D-Air-2 at 0.25% by weight of pozzolans.
(7) Additive Mixture: Added superplasticizer at 1.67% by weight of pozzolan.
(8) Additive Mixture: Added D-Air-2 at 0.25% and superplasticizer at 1.67% by weight of pozzolan.
(9) 1 ml free liquid present on top of hardened cylinder after 28-day cure.
(10) 2 ml free liquid present on top of hardened cylinder after 28-day cure.
(11) 3 ml free liquid present on top of hardened cylinder after 28-day cure.
(12) 6 ml free liquid present on top of hardened cylinder after 28-day cure.
(13) 8 ml free liquid present on top of hardened cylinder after 28-day cure.

NT - Not tested for this parameter.

TABLE 3-10
207C CLARIFIER MIXES
LIME, CEMENT AND FLYASH
FREE LIQUID TEST CRITERIA

Batch No.	Date Mixed	Paint Filter Liquids Test(1)		Liquid/Solids Test(2)	
		Pass	Fail	Pass	Fail
1C	4/1/92	X		X	
2C	4/1/92	X		X	
3C	4/1/92	X		X	
4C	4/1/92	X		X	
5C	4/1/92	X		X	
6C	4/1/92	X		X	
7C	4/6/92	X		X	
8C	4/6/92	X		X	
9C	4/6/92	X		X	
10C	4/6/92	X		X	
11C	4/6/92	X		X	
12C	4/6/92	X		X	
13C	4/6/92	X		X	
14C	4/6/92	X		X	
15C(3)	5/13/92	X		X	
16C(4)	5/13/92	X		X	
17C(5)	5/13/92	X		X	

(1) Paint Filter Liquids Test - SW846, Method 9095
(2) ASTM D4359-84 - Standard Test Method for Determining Whether a Material is a Liquid or a Solid.
(3) Additive Mixture: Added D-Air-2 at 0.25% by weight of pozzolans.
(4) Additive Mixture: Added superplasticizer at 1.67% by weight of pozzolans.
(5) Additive Mixture: Added D-Air-2 at 0.25% and superplasticizer at 1.67% by weight of pozzolans.

and flyash. Tables 3-11 and 3-12 provide the results for the batches mixed with Pond 207C water and silt, and the batches mixed with Pond 207C slurry and the clarifier sludge, respectively. These batches were prepared with lime, cement, flyash, and Latex 2000.

All of the batches prepared in the final phase of testing successfully passed both tests for the determination of free liquid after 28 days of curing except Batches 26, 27, 29, and 30. These batches were prepared with a superplasticizer (cement retarder) in which the dosage was too high. Because the dosage was too high, the pozzolans did not cure, and as a result free liquid was present after 28-days of curing.

The 28-day cured samples with 207C water and silty sludge (Batches 1 - 5 on Table 3-9 and Batches 1L - 9L on Table 3-11) all passed the Paint Filter Liquids Test (SW 9095). However, the liquid/solids test (ASTM D4359-84) was not conducted on these batches.

Additional testing was conducted on both Pond 207C material and the combined slurry of 207C and Clarifier to determine the time required for the waste material, once mixed with pozzolans, to solidify sufficiently to pass the free liquids testing criteria. The testing was conducted at a water to pozzolan ratio of 0.50. This condition would require the longest time to pass the test because this condition has the least amount of pozzolans.

The test for the liquid/solids test (Method ASTM 4359-84) was modified for this procedure. The test method requires that the sample be dried at 100°F for 24 hours. Because this would accelerate the curing of the material, the method was modified by eliminating the drying portion. The test cylinders were air-cured, which is more representative of expected field conditions.

The test conducted for Pond 207C slurry used a cement to flyash ratio of 1 to 2 and a water to pozzolan ratio of 0.50. The solids data for the waste tested are as follows:

- Total dissolved solids = 33.1%
- Total suspended solids = 7.4%
- Total solids = 35.0%

TABLE 3-11
207C WATER AND SILT MIXES
LIME, CEMENT, FLYASH, AND LATEX
FREE LIQUID TEST CRITERIA

Batch	Date Mixed	Paint Filter Liquids Test(1)		Liquid/Solids Test(2)	
		Pass	Fail	Pass	Fail
1L	2/13/92	X		NT	NT
2L	2/13/92	X		NT	NT
3L	2/13/92	X		NT	NT
4L	2/13/92	X		NT	NT
5L	2/13/92	X		NT	NT
6L	2/13/92	X		NT	NT
7L	2/13/92	X		NT	NT
8L	2/13/92	X		NT	NT
9L	2/13/92	X		NT	NT
10L	4/2/92	X		X	
11L	4/2/92	X		X	
12L	4/2/92	X		X	
13L	4/2/92	X		X	
14L	4/2/92	X		X	
15L	4/3/92	X		X	
16L	4/3/92	X		X	
17L	4/3/92	X		X	
18L	4/3/92	X		X	
19L	4/3/92	X		X	

(1) *Paint Filter Liquids Test - SW846, Method 9095*
(2) ASTM D4359-84 - Standard Test Method for Determining Whether a Material is a Liquid or a Solid.

NT - Not Tested For This Parameter

TABLE 3-12
207C SLURRY AND CLARIFIER MIXES
LIME, CEMENT, FLYASH, AND LATEX
FREE LIQUID TEST CRITERIA

Batch	Date Mixed	Paint Filter Liquids Test(1)		Liquid/Solids Test(2)	
		Pass	Fail	Pass	Fail
1CL	4/6/92	X		X	
2CL	4/6/92	X		X	
3CL	4/6/92	X		X	
4CL	4/6/92	X		X	
5CL	4/6/92	X		X	

(1) Paint Filter Liquids Test - SW 846, Method 9095
(2) ASTM D4359-84 - Standard Test Method for Determining Whether a Material is a Liquid or a Solid.

The solidified material passed both the paint filter test and the liquid/solids test after 12 hours.

The test conducted for the combined slurry of Pond 207C and the Clarifier used a cement of flyash ratio of 1 to 2 and a water to pozzolan ratio of 0.50. The solids data for the waste tested are as follows:

- Total dissolved solids = 34.6%
- Total suspended solids = 11.6%
- Total solids = 38.9%

The solidified material passed both the paint filter test and the liquid/solids test after 4 hours.

3.1.2 Results of Engineering Testing

Unconfined compressive strength (UCS), freeze/thaw durability, and wet/dry durability were measured during the regulatory confirmation phase on 28-day cured samples. These parameters are not mandatory for the final solidified product to be certified prior to ultimate disposal. These tests are pertinent for estimating the stability of the end product and provide comparative data between various CSS formulas.

3.1.2.1 Unconfined Compressive Strength

Test cylinders that have Unconfined Compressive Strength (UCS) results that approach 600 psi typically have passed the regulatory criteria and the durability tests. However, it can not be assumed that UCS results less than 600 psi will fail all other criteria because there is not a direct correlation between UCS data and other acceptance criteria or engineering data.

The results of the UCS tests are provided in Tables 3-13 to 3-16. Table 3-13 provides the data for the batches prepared with lime, cement, and flyash using Pond 207C water and silt. Table 3-14 provides the data for batches prepared using lime, cement, flyash using Pond 207C slurry with the clarifier. Tables 3-15 and 3-16 provide the data for the batches prepared with lime, cement, flyash, and Latex 2000 using Pond 207C water and silt and Pond 207C slurry with the clarifier, respectively.

TABLE 3-13
207C WATER AND SILT
LIME/CEMENT/FLYASH
UNCONFINED COMPRESSIVE STRENGTH RESULTS

Batch No.	Date Mixed	Water/ Pozzolan Ratio	7 Day UCS (PSI)	28 Day UCS (PSI)	52 Day UCS Wet/Dry Control (PSI)	52 Day UCS Wet/Dry Scratch (PSI)	52 Day UCS Freeze/Dry Scratch (PSI)	52 Day UCS Freeze/Thaw Scratch (PSI)
1	2/13/92	0.36	>637	428	>637	>637	>637	>637
2	2/13/92	0.42	>637	>637	>637	>637	>637	>637
3	2/13/92	0.44	319	626	>637	>637	319	61
4	2/13/92	0.46	>637	>637	>637	>637	>637	>637
5	2/13/92	0.56	>637	448	481	489	363	491
6	4/6/92	0.34	>637	590	560	>637	>637	>637
7	4/6/92	0.42	>637	280	>637	>637	>637	>637
8	4/6/92	0.50	>637	231	211	>637	282	>637
9	4/3/92	0.34	>637	>637	>637	>637	>637	>637
10	4/3/92	0.42	>637	321	>637	541	528	>637
11	4/3/92	0.50	>637	550	326	>637	>637	>637
12	4/2/92	0.34	>637	>637	378	>637	516	>637
13	4/2/92	0.38	>637	>637	>637	>637	>637	>637
14	4/2/92	0.42	>637	566	>637	>637	>637	192
15	4/2/92	0.46	>637	590	>637	>637	>637	>637
16	4/2/92	0.50	106	>637	398	166	>637	231
17	4/2/92	0.42	>637	595	>637	>637	>637	>637
18	4/2/92	0.50	>637	>637	581	388	>637	>637

TABLE 3-13
207C WATER AND SILT
LIME/CEMENT/FLYASH
UNCONFINED COMPRESSIVE STRENGTH RESULTS
PAGE TWO

Batch No.	Date Mixed	Water/ Pozzolan Ratio	7 Day UCS (PSI)	28 Day UCS (PSI)	52 Day UCS Wet/Dry Control (PSI)	52 Day UCS Wet/Dry Scratch (PSI)	52 Day UCS Freeze/Dry Scratch (PSI)	52 Day UCS Freeze/Thaw Scratch (PSI)
19	4/3/92	0.38	>637	>637	>637	>637	>637	>637
20	4/3/92	0.42	599	233	>637	>155	>637	>637
21	4/3/92	0.48	>637	>637	437	508	>637	>637
22	4/3/92	0.34	>637	>637	360	>637	>637	>637
23	4/3/92	0.42	>637	>637	555	565	>637	>637
24	4/3/92	0.50	481	259	97	Failed	620	618
25	5/13/92	0.42	478	>637	>637	>637	>637	>637
26	5/13/92	0.42	6.3	TSTT	TNP	TNP	TNP	TNP
27	5/13/92	0.42	13	TSTT	TNP	TNP	TNP	TNP
28	5/13/92	0.42	359	462	>637	454	460	521
29	5/13/92	0.42	20	TSTT	TNP	TNP	TNP	TNP
30	5/13/92	0.42	11	TSTT	TNP	TNP	TNP	TNP

1. Pozzolan consists of Type V cement and Type C flyash.
2. The maximum psi which can be determined by the testing equipment is 637 psi.
3. See Table 2-2 for waste loadings.

TSTT - To soft to test, cylinder failed when removing from plastic mold.
TNP - Test not performed.

TABLE 3-14
207C WATER AND CLARIFIER SLUDGE
LIME/CEMENT/FLYASH
UNCONFINED COMPRESSIVE STRENGTH RESULTS

Batch No.	Date Mixed	Water/ Pozzolan Ratio	7 Day UCS (PSI)	28 Day UCS (PSI)	52 Day UCS Wet/Dry Control (PSI)	52 Day UCS Wet/Dry Scratch (PSI)	52 Day UCS Freeze/Thaw Control (PSI)	52 Day UCS Freeze/Thaw Scratch (PSI)
1C	4/1/92	0.34	>637	>637	>637	>637	>637	>637
2C	4/1/92	0.42	>637	>637	376	551	>637	>637
3C	4/1/92	0.50	>637	>637	204	Failed	>637	>637
4C	4/6/92	0.34	>637	>637	>637	>637	>637	>637
5C	4/6/92	0.38	>637	389	>637	>637	>637	>637
6C	4/6/92	0.42	>637	>637	>637	>637	>637	>637
7C	4/6/92	0.46	>637	620	>637	>637	418	269
8C	4/6/92	0.50	>637	167	>637	>637	177	152
9C	4/6/92	0.50	>637	>637	>637	>637	>637	>637
10C	4/6/92	0.34	>637	>637	>637	>637	>637	>637
11C	4/6/92	0.38	>637	>637	>637	>637	>637	608
12C	4/6/92	0.42	>637	>637	>637	>637	>637	>637
13C	4/6/92	0.46	>637	>637	>637	>637	>637	>637
14C	4/6/92	0.50	613	246	>637	411	>637	>637
15C	5/13/92	0.42	>637	>637	>637	551	>637	369
16C	5/13/92	0.42	26	22	TNP	TNP	TNP	TNP
17C	5/13/92	0.42	26	7.3	TNP	TNP	TNP	TNP

1. Pozzolan consists of Type V cement and Type C flyash.
2. The maximum UCS which can be determined by the testing equipment is 637 psi.
3. See Table 2-3 for waste loadings.

TNP - Test not performed.

TABLE 3-15
207C WATER AND SILT
LIME/CEMENT/FLYASH/LATEX
UNCONFINED COMPRESSIVE STRENGTH RESULTS

Batch No.	Date Mixed	Water/ Pozzolan Ratio	7 Day UCS (PSI)	28 Day UCS (PSI)	52 Day UCS Wet/Dry Control (PSI)	52 Day UCS Wet/Dry Scratch (PSI)	52 Day UCS Freeze/Dry Scratch (PSI)	52 Day UCS Freeze/Thaw Scratch (PSI)
1L	2/13/92	0.42	>637	>637	>637	>637	>637	>637
2L	2/13/92	0.36	>637	>637	>637	>637	>637	624
3L	2/13/92	0.56	151	>637	476	118	>637	>637
4L	2/13/92	0.46	>637	>637	>637	>637	>637	>637
5L	2/13/92	0.44	580	>637	>637	>637	>637	>637
6L	2/13/92	0.42	>637	>637	>637	>637	>637	>637
7L	2/13/92	0.36	>637	>637	445	Failed	>637	449
8L	2/13/92	0.56	>637	>637	565	560	>637	>637
9L	2/13/92	0.46	599	>637	>637	>637	>637	>637
10L	4/2/92	0.50	>637	>637	617	537	>637	>637
11L	4/2/92	0.50	>637	>637	>637	>637	>637	>637
12L	4/2/92	0.34	>637	>637	>637	>637	>637	>637
13L	4/2/92	0.34	>637	>637	>637	>637	>637	>637
14L	4/2/92	0.42	>637	>637	>637	>637	>637	518
15L	4/3/92	0.50	338	>637	>637	>637	>637	>637
16L	4/3/92	0.34	>637	>637	>637	>637	>637	>637
17L	4/3/92	0.42	>637	>637	>637	>637	>637	>637
18L	4/3/92	0.50	487	>637	>637	Failed	>637	>637
19L	4/3/92	0.34	>637	>637	>637	>637	>637	>637

1. Pozzolan consists of Type V cement and Type C flyash.
2. The maximum UCS which can be determined by the testing equipment is 637 psi.
3. See Table 2-4 for waste loadings.

TABLE 3-16
207C WATER AND CLARIFIER SLUDGE
LIME/CEMENT/FLYASH/LATEX
UNCONFINED COMPRESSIVE STRENGTH RESULTS

Batch No.	Date Mixed	Water/ Pozzolan Ratio	7 Day UCS (PSI)	28 Day UCS (PSI)	52 Day UCS Wet/Dry Control (PSI)	52 Day UCS Wet/Dry Scratch (PSI)	52 Day UCS Freeze/Dry Scratch (PSI)	52 Day UCS Freeze/Thaw Scratch (PSI)
1CL	4/6/92	0.34	>637	>637	>637	>637	>637	>637
2CL	4/6/92	0.42	>637	>637	>637	>637	Failed	Faailed
3CL	4/6/92	0.34	>637	>637	>637	>637	>637	>637
4CL	4/6/92	0.50	>637	>637	>637	>637	>637	>637
5CL	4/6/92	0.50	>637	>637	483	347	114	79

1. Pozzolan consists of Type V cement and Type C flyash.
2. The maximum UCS which can be determined by the testing equipment is 637 psi.
3. See Table 2-5 for waste loadings.

The results presented in Table 3-13 and 3-14 indicate all tested batches achieved greater than 100 psi after the 7-day and 28-day curing. The data shown for 52-day UCS are after the samples were subjected to the wet/dry and the freeze/thaw durability tests. After 7 days, most batches achieved greater than 637 psi, the maximum reading the equipment was capable of producing. However, there is an apparent decrease in strength from 7 days to 28 days with 12 of the 24 batches showing a lower UCS value. This apparent trend of decreasing strength over time is not supported by the 52-day UCS data. When the 7-day and 28-day data are compared to the 52-day UCS data, even after going through durability testing, the strengths are equal to or greater than the original 7-day UCS values.

There are several possible explanations for the observed loss in strength for the 28-day UCS analyses, which was not observed for the 52-day UCS analyses. One explanation is that the cylinders did not have completely flat surfaces, which resulted in stress from the UCS machine being applied unevenly, resulting in an artificially low UCS value. Following the ASTM Method D4219-83, Standard Test Method for Unconfined Compressive Strength Index of Chemically Grouted Soils, the samples were not required to be prepared using a polishing or capping procedure to assure a flat, level surface. Due to the large number of test cylinders and the time constraints, it was not feasible to prepare the samples in this way. ASTM D4219-83 does call for the ends of the specimens to be smooth, perpendicular to the longitudinal axis, and of the same diameter of the specimen, which was the case for most of the cylinders tested. A second explanation is that the cylinders could have been handled or filled improperly. It was noted during the treatability study that improperly packing or filling the cylinders could have a dramatic effect on the strength of the cured cylinders. It is also possible that the cylinders chosen were of lesser quality. At this time, there is insufficient data to determine the specific cause of the loss of strength after 28 days. However, long-term (52-day) UCS data indicate there is no trend for loss of strength with time.

Also shown in Table 3-13 are Batches 25 and 28, which represent the batches prepared with the D-Air-2 defoaming additive. The UCS values for these batches were in an acceptable range. Batches 26, 27, 29, and 30 are those batches which were prepared with the Halliburton superplasticizer to improve viscosity. The UCS results for these batches are unacceptable and are an indication that the plasticizer dosage was too high.

Table 3-14 provides UCS data for Batch 15C, which is the batch prepared with D-Air-2. This result is acceptable. Batches 16C and 17C are those prepared with the superplasticizer. These results are also unacceptable and indicate that the superplasticizer dosage was too high.

The UCS results for batches prepared with lime/cement/flyash/Latex 2000, shown in Tables 3-15 and 3-16, all achieved the maximum value of 637 psi for the 28-day cure samples. Five of the 19 batches of 207C water/silt prepared with the latex additive were below the maximum measurable UCS value after 7 days of curing, but all achieved greater than 637 psi after 28 days. All five batches of 207C/clarifier prepared with the latex additive achieved 637 psi after 7 days, and maintained greater than 637 psi after 28 days. Long-term (52-day) UCS data also showed favorable results by maintaining the high UCS's results.

3.1.2.2 Durability Testing

The long-term durability testing provides an indication of the final end product's ability to withstand environmental conditions such as moisture and temperature variations. However, successfully passing these tests can not be related to a particular time frame in which the half crates will remain intact if exposed to the environment.

The durability test results for Batches 1 to 24, the lime/cement/flyash mixes for 207C water and silt, are provided in Table 3-17. All of the batches successfully passed the 12 cycles for the wet/dry and the freeze/thaw tests with the exception of Batch 24, which failed the wet/dry test in Cycle 9. Batch 24 was prepared at a water to pozzolan ratio of 0.50 with a solids loading 49.1%. This was the most stringent condition tested. This condition (high solids and a .50 water to pozzolan ratio) will not likely be encountered during remediation.

It can be seen that the UCS results after the durability testing decreased very little, if at all. In some cases the UCS results increased. The exception was, Batch 3 (freeze/thaw), Batch 18 (wet/dry), and Batch 21 (wet/dry), which had a significant decrease in strength for both the scratched and control cylinder. The low UCS for the scratched cylinder may be a result of the surfaces of the cylinder not being flat, which resulted in an artificially low UCS result. The change in weight for the control vs. the scratched cylinder is similar, which indicates that only small amounts of the scratched cylinder were removed by the scratching.

TABLE 3-17
207C WATER
LIME, CEMENT AND FLYASH
FINAL PHASE FREEZE/THAW AND WET/DRY

Batch	W/P	Durability: Wet/Dry: Initial: UCS (psi)	Wet/Dry: Final: Control % Wt. Loss	Wet/Dry: Final: Scratched % Wt. Loss	Wet/Dry: Final: Control UCS (psi)	Wet/Dry: Final: Scratched UCS (psi)	Freeze/Thaw: Initial: UCS (psi)	Freeze/Thaw: Final: Control % Wt. Loss(7)	Freeze/Thaw: Final: Scratched % Wt. Loss(7)	Freeze/Thaw: Final: Control UCS (psi)	Freeze/Thaw: Final: Scratched UCS (psi)
1. (2/13/92)	0.36	428	15.2%	16.7%	>637	>637	428	0.4%	1.5%	>637	>637
2. (2/13/92)	0.42	>637	6.8%	9.0%	>637	>637	>637	-0.5%	0.3%	>637	>637
3. (2/13/92)	0.44	626	19.5%	25.5%	>637	>637	626	-0.4%	2.2%	319	61
4. (2/13/92)	0.46	>637	11.2%	13.6%	>637	>637	>637	-1.5%	0.7%	>637	>637
5. (2/13/92)	0.56	448	12.8%	13.8%	481	489	448	-1.0%	0.3%	363	491
6. (4/6/92)	0.34	590	9.5%	9.2%	560	>637	590	-0.4%	0.2%	>637	>637
7. (4/6/92)	0.42	280	12.1%	11.8%	>637	>637	280	-0.4%	0.3%	>637	>637
8. (4/6/92)	0.50	231	15.4%	17.1%	211	>637	231	0.1%	1.3%	282	>637
9. (4/3/92)	0.34	>637	10.2%	10.4%	>637	>637	>637	0.09%	1.0%	>637	>637
10. (4/3/92)	0.42	321	13.0%	14.0%	541	326	321	0.2%	1.8%	528	>637
11. (4/3/92)	0.50	550	17.0%	17.4%	>637	>637	550	-0.1%	1.2%	>637	>637
12. (4/2/92)	0.34	>637	10.1%	11.2%	378	>637	>637	-0.3%	0.6%	516	>637
13. (4/2/92)	0.38	>637	10.7%	10.3%	>637	>637	>637	-0.1%	0.7%	>637	>637
14. (4/2/92)	0.42	566	12.7%	13.2%	>637	>637	566	-0.1%	1.3%	>637	192
15. (4/2/92)	0.4	590	15.0%	15.4%	>637	>637	590	0.05%	1.8%	>637	>637
16. (4/2/92)	0.50	>637	18.7%	19.9%	398	166	>637	0.03%	1.9%	>637	231
17. (4/2/92)	0.42	595	15.7%	16.1%	>637	>637	595	0.1%	1.4%	>637	>637
18. (4/2/92)	0.50	>637	21.2%	25.0%	581	388	>637	0.1%	2.5%	>637	>637
19. (4/3/92)	0.38	>637	13.5%	13.6%	>637	>637	>637	-0.2%	1.6%	>637	>637
20. (4/3/92)	0.42	233	17.0%	18.0%	>637	155	233	0.5%	1.6%	>637	>637
21. (4/3/92)	0.48	>637	19.2%	20.0%	437	508	>637	0.4%	1.9%	>637	<637
22. (4/3/92)	0.34	>637	14.1%	14.3%	360	>637	>637	-0.2%	1.0%	>637	>637
23. (4/3/92)	0.42	>637	16.3%	19.1%	555	565	>637	0.1%	2.1%	>637	>637
24. (4/3/92)	0.50	259	25.7%	Failed, Cycle #9	97	NA	259	1.3%	4.8%	620	618

TABLE 3-17
207C WATER
LIME, CEMENT AND FLYASH
FINAL PHASE FREEZE/THAW AND WET/DRY
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Batch	W/P	Durability									
		Wet/Dry					Freeze/Thaw				
		Initial	Final				Initial	Final			
		UCS (psi)	Control % Wt. Loss	Scratched % Wt. Loss	Control UCS (psi)	Scratched UCS (psi)	UCS (psi)	Control % Wt. Loss(7)	Scratched % Wt. Loss(7)	Control UCS (psi)	Scratched UCS (psi)
25. (5/13/92)(1)	0.42	>637	15.0%	15.5%	>637	>637	>637	-0.4%	0.6%	>637	>637
26. (5/13/92)(2)	0.42	TSTT	NTP	NTP	NA	NA	TSTT	NTP	NTP	NA	NA
27. (5/13/92)(3)	0.42	TSTT	NTP	NTP	NA	NA	TSTT	NTP	NTP	NA	NA
28. (5/13/92)(4)	0.42	462	16.2%	16.7%	>637	454	462	-0.7%	1.0%	460	521
29. (5/13/92)(5)	0.42	TSTT	NTP	NTP	NA	NA	TSTT	NTP	NTP	NA	NA
30. (5/13/92)(6)	0.42	TSTT	NTP	NTP	NA	NA	TSTT	NTP	NTP	NA	NA

NOTES:

Samples cured for 28 days before start of durability testing.

(1) Additive Mixture: Added D-Air-2 at 0.25% of total pozzolan weight.
(2) Additive Mixture: Added superplasticizer at 1.67% by weight of pozzolans.
(3) Additive Mixture: Added D-Air-2 at 0.25% and superplasticizer at 1.67% by weight of pozzolans.
(4) Additive Mixture: Added D-Air-2 at 0.25% by weight of pozzolans.
(5) Additive Mixture: Added superplasticizer at 1.67% by weight of pozzolan.
(6) Additive Mixture: Added D-Air-2 at 0.25% and superplasticizer at 1.67% by weight of pozzolan.
(7) Negative Value indicated a gain in weight after durability testing.

NT - Not tested for this parameter.
TSTT - Too soft to test, cylinder broke when removed from plastic cylinder.
NA - Not Analyzed.
NTP - No Test Performed.

The durability test results for Batches 1L to 19L, the lime/cement/flyash/latex mixes for 207C water, are provided in Table 3-18. All of the batches successfully passed the 12 cycles for the wet/dry and the freeze/thaw tests with the exception of Batches 7L and 18L. Both Batches 7L and 18L failed the wet/dry testing. Batch 18L is at a water to pozzolan ratio of 0.50 and a solids loading of 49.1%. These are the same conditions as Batch 24. There is no apparent reason why Batch 7L failed. A possible reason is that the cylinders was not packed or handled properly.

It can be seen that the UCS results, after the durability testing, did not change significantly from those before the durability testing. The changes in weight for the control vs. the scratches cylinder are similar, which indicates that only small amounts of the scratches cylinder were removed by the scratching.

The durability test results for Batches 1C to 17C are provided in Table 3-19. These batches were prepared with lime/cement/flyash for Pond 207C and the clarifier. Only Batch 3C failed in the wet/dry test. This batch was prepared at a water to pozzolan ratio of 0.50.

The UCS results after the durability test are all in an acceptable range. Only Batch 2C shows a decrease in strength for both the scratched and control cylinder.

The density test results for Batch 1CL to 5CL are shown in table 3-20. These batches were prepared with 207C slurry and clarifier sludge with lime/cement/flyash plus latex. Batch 2CL failed the freeze/thaw test, although there does not appear to be apparent reason for the failure. This batch was at a water to pozzolan ratio of 0.42. Batches with similar waste loading at a water to pozzolan ratio of 0.50 successfully passed the durability testing.

3.1.2.3 Petrographic Analysis

Petrographic analysis was conducted on test cylinders from Phase I/II and the regulatory phase (Phase III/IV) of the treatability study. Petrographic analysis was conducted by following ASTM Method 6856-77. The primary purpose of the petrographic analysis was to microscopically determine if there were any significant defects in the CCS formulations that were not apparent from the macro-testing which was conducted.

TABLE 3-18
207C WATER LIME, CEMENT, FLYASH AND LATEX
FINAL PHASE FREEZE/THAW AND WET/DRY

Batch	W/P	Durability									
		Wet/Dry					Freeze/Thaw				
		Initial	Final				Initial	Final			
		UCS (psi)	Control % Wt. Loss	Scratched % Wt. Loss	Control UCS (psi)	Scratched UCS (psi)	UCS (psi)	Control % Wt. Loss(1)	Scratched % Wt. Loss(1)	Control UCS (psi)	Scratched UCS (psi)
1L (2/13/92)	0.42	>637	12.7%	15.1%	>637	>637	>637	-0.03%	0.9%	>637	>637
2L (2/13/92)	0.36	>637	11.7%	15.5%	>637	>637	>637	-1.5%	1.0%	>637	>637
3L (2/13/92)	0.56	>637	16.3%	22.1%	476	118	>637	-0.8%	1.4%	>637	624
4L (2/13/92)	0.46	>637	11.4%	14.8%	>637	>637	>637	-0.7%	0.4%	>637	>637
5L (2/13/92)	0.44	>637	13.5%	16.7%	>637	>637	>637	-0.5%	0.8%	>637	>637
6L (2/13/92)	0.42	>637	13.1%	16.9%	>637	>637	>637	-0.2%	1.4%	>637	>637
7L (2/13/92)	0.36	>637	14.2%	Failed, Cycle #10	445	NA	>637	1.1%	6.2%	>637	449
8L (2/13/92)	0.56	>637	15.1%	20.3%	565	560	>637	-1.1%	1.9%	>637	>637
9L (2/13/92)	0.46	>637	12.9%	15.3%	>637	>637	>637	-0.9%	0.3%	>637	>637
10L (4/2/92)	0.5	>637	19.8%	20.1%	617	537	>637	0%	1.9%	>637	>637
11L (4/2/92)	0.5	>637	20.4%	20.6%	>637	>637	>637	-0.03%	2.3%	>637	>637
12L (4/2/92)	0.34	>637	10.1%	10.6%	>637	>637	>637	0.05%	1.1%	>637	>637
13L (4/2/92)	0.34	>637	10.2%	11.0%	>637	>637	>637	0.02%	1.0%	>637	>637
14L (4/2/92)	0.42	>637	15.8%	17.2%	>637	>637	>637	0.08%	1.3%	>637	518
15L (4/3/92)	0.50	>637	17.0%	18.4%	>637	>637	>637	-0.02%	1.5%	>637	>637
16L (4/3/92)	0.34	>637	10.2%	10.5%	>637	>637	>637	0.1%	1.4%	>637	>637
17L (4/3/92)	0.42	>637	14.4%	15.4%	>637	>637	>637	0.2%	1.9%	>637	>637
18L (4/3/92)	0.50	>637	22.9%	Failed, Cycle #10	>637	NA	>637	1.5%	4.2%	>637	>637
19L (4/3/92)	0.34	>637	13.8%	14.5%	>637	>637	>637	0.7%	1.9%	>637	>637

TABLE 3-18
207C WATER LINE, CEMENT, FLYASH AND LATEX
FINAL PHASE FREEZE/THAW AND WET/DRY
PAGE TWO

Sample cured for 28 days then started durability testing.

(1) Negative value indicated a gain in weight after durability analysis.

TABLE 3-19
207C AND CLARIFIER MIXES
LIME, CEMENT, FLYASH
FINAL PHASE FREEZE/THAW AND WET/DRY

Batch	W/P	Durability									
		Wet/Dry					Freeze/Thaw				
		Initial	Final				Initial	Final			
		UCS (psi)	Control % Wt. Loss	Scratched % Wt. Loss	Control UCS (psi)	Scratched UCS (psi)	UCS (psi)	Control % Wt. Loss(4)	Scratched % Wt. Loss(4)	Control % UCS (psi)	Scratched UCS (psi)
1C (4/1/92)	0.34	>637	10.1%	10.4%	>637	>637	>637	-0.2%	0.5%	>637	>637
2C (4/1/92)	0.42	>637	13.8%	13.4%	376	552	>637	-0.6%	0.3%	>637	>637
3C (4/1/92)	0.50	>637	21.0%	Failed, Cycle #10	204	NA	>637	-1.1%	0.2%	>637	>637
4C (4/6/92)	0.34	>637	10.3%	10.2%	>637	>637	>637	-0.5%	0.1%	>637	>637
5C (4/6/92)	0.38	389	12.6%	13.7%	>637	>637	389	-0.7%	0.3%	>637	>637
6C (4/6/92)	0.42	>637	15.1%	16.0%	>637	>637	>637	-0.6%	0.6%	>637	>637
7C (4/6/92)	0.46	620	15.3%	16.1%	>637	>637	620	-0.8%	0.7%	418	269
8C (4/6/92)	0.50	167	18.9%	19.4%	>637	>637	167	-0.5%	1.4%	177	152
9C (4/6/92)	0.50	>637	16.1%	16.5%	>637	>637	>637	-0.5%	0.8%	>637	>637
10C (4/6/92)	0.34	>637	11.0%	10.8%	>637	>637	>637	-0.6%	-0.2%	>637	>637
11C (4/6/92)	0.38	>637	13.4%	13.0%	>637	>637	>637	0.2%	0.7%	>637	608
12C (4/6/92)	0.42	>637	15.6%	14.7%	>637	>637	>637	0.3%	1.3%	>637	>637
13C (4/6/92)	0.46	>637	17.2%	17.2%	>637	>637	>637	0.5%	1.5%	>637	>637
14C (4/6/92)	0.50	246	17.5%	17.2%	>637	411	246	0.7%	1.6%	>637	>637
15C (5/13/92)(1)	0.42	>637	16.1%	16.1%	>637	551	>637	-0.3%	0.9	>637	369
16C (5/13/92)(2)	0.42	22	Failed, Cycle #3	Failed, Cycle #3	NA	NA	22	-1.6%	Failed, Cycle #1	412	NA
17C (5/13/92)(3)	0.42	7.3	Failed, Cycle #3	Failed, Cycle #3	NA	NA	7.3	Failed, Cycle #2	Failed, Cycle #2	NA	NA

TABLE 3-19
207C AND CLARIFIER MIXES
LIME, CEMENT, FLYASH
FINAL PHASE FREEZE/THAW AND WET/DRY
PAGE TWO

(1) Additive Mixture: Added D-Air-2 at 0.14% of total by weight.
(2) Additive Mixture: Added superplasticizer at 0.96% by total by weight of total.
(3) Additive Mixture: Added D-Air-2 at 0.14% of total by weight and superplasticizer of 0.96% of total by weight.
(4) Negative value indicated a gain in weight after durability analysis performed.

Samples cured for 28 days before start of durability testing.

NA - Sample failed test therefore not available for UCS testing.

TABLE 3-20
207C AND CLARIFIER MIXES
LIME, CEMENT, FLYASH, AND LATEX
FINAL PHASE FREEZE/THAW AND WET/DRY

		Durability									
		Wet/Dry					Freeze/Thaw				
		Initial	Final				Initial	Final			
Batch	W/P	UCS (psi)	Control % Wt. Loss	Scratched % Wt. Loss	Control UCS (psi)	Scratched UCS (psi)	UCS (psi)	Control % Wt. Loss(1)	Scratched % Wt. Loss(1)	Control % UCS (psi)	Scratched UCS (psi)
1CL (4/6/92)	0.34	>637	10.1%	12.7%	>637	>637	>637	-0.4%	0.5%	>637	>637
2CL (4/6/92)	0.42	>637	20.1%	21.5%	>637	>637	>637	Failed, Cycle #9	Failed, Cycle #8	NA	NA
3CL (4/6/92)	0.34	>637	15.0%	14,4%	>637	>637	>637	-0.5%	1.1%	>637	>637
4CL (4/6/92)	0.50	>637	10.4%	12.5%	>637	>637	>637	-0.4%	0.4%	>637	>637
5CL (4/6/92)	0.50	>637	17.1%	18.8%	483	347	>637	-0.4%	1.4%	114	79

Samples cured for 28 days before start of durability testing.

(1) Negative value indicated a gain in weight after durability testing.

NA - Sample failed durability testing therefore not available for UCS testing.

The microscopic analysis is conducted by evaluating numerous test cylinders to look for patterns or trends upon which to base conclusions. Trends such as microcracking, poor gel formation, and cement hydration are evauated to determine if they correlate to salt loadings, suspended solids loadings, and/or water to pozzolan ratios.

The results of the petrographic analysis of the test cylinders from Phase I/II indicated that Latex 2000 improved the cement hydration and reduced the microcracks. Because of this evaluation, the Latex 2000 System was retained for further evaluation in the regulatory phase of testing.

The results of the petrographic analysis of the test cylinders from the regulatory phase confirmed that the Latex 2000 System is a beneficial additive with regards to reducing crystal growth, porosity, and microcracking. The cylinders with latex also had adequate cement hydration and good gel formation. Evaluation of the Latex 2000 dosage indicated that 1% by weight of cement did not offer any significant improvement of the above characteristics. A dosage of 3% provided an indication that there was an improvement, and a 5% dosage was determined to have the best qualities.

The evaluation of the water to pozzolan ratios indicated that the lower ratios produced a solidified waste material which had less crystal growth and cracking compared to the higher ratios. Additionally, lower salt and solids loadings were considered to produce a solidified waste material which has less detrimental effects than those cylinders with higher salt and solids loadings.

A general observation made was that the test cylinders which were not removed from the plastic curing containers had better microscopic characteristics compared to cylinders which were exposed to the atmosphere. In several instances, when the test cylinders were removed from the curing containers, crystal growth began immediately. This suggests that sealing the half crates inside of a bladder and a plastic bag may be beneficial with regards to crystal growth.

In general, it was concluded that the test cylinders prepared at low water to pozzolan ratios with 5% latex and low solids (i.e., salt and suspended solids) had the best qualities for long-term durability.

3.2 PROCESS FORMULATION DEVELOPMENT (LIME/CEMENT/FLYASH)

This section provides a discussion of the treatability study results regarding development of an operating range for remediation. The overall objective of the treatability study was to provide legally defensible data for input to the Process Control Plan, thereby providing information to be used to certify the final waste form.

As previously mentioned, the treatability study initially evaluated various combinations of binder formulations to determine which additives resulted in a product that was stable and passed all of the NTS acceptance criteria. Once it was determined that a specified formulation resulted in an acceptable end product, testing was conducted to develop an operating range which could be used during remediation. The operating range was developed to be conservative enough to ensure that all samples passed the required criteria. Because of schedule constraints, the operating range was not pushed to greater limits which would determine the points of failure.

Based on the treatability testing, two parameters appear to be the most significant regarding process control. The first is the blending of the pozzolanic mixture, and the second is the ratio of water to pozzolans in the process stream. Other parameters such as salt loading, solids loading, and concentrations of metals in the raw product have not demonstrated significance for the certification of the final product at the levels tested. It is possible that higher loadings might affect product certification. In other words, the testing indicates that if the first two parameters are correctly controlled and the other parameters (i.e., salt loading and solid loadings) are maintained within the ranges tested during the treatability study, then the resulting end product should pass all of the certification criteria. However, because the testing did not attempt to determine the failure point of the formulation, the operating envelope will have a ceiling limit for the salt loading and solid loadings based on the limits actually tested during the treatability study.

3.2.1 <u>CSS Binder Formulation</u>

3.2.1.1 Cement/Flyash Ratios

The testing conducted for Pond 207C typically evaluated binder formulations of cement and flyash at varying ratios. The final phase of testing evaluated formulations using Type C flyash and Type V cement.

Pond 207C

The ratio of cement to flyash was selected at 1 to 2 for the midpoint of the factorial experiments conducted during the preliminary testing. The factorial experiments were designed to vary the cement and flyash quantities plus and minus 25 percent around the midpoint quantity. This resulted in a cement to flyash ratio which ranged from 1/1.2 to 1/3.34. All preliminary testing was conducted in this manner and all of the preliminary acceptance criteria were passed. Additionally, Batch 2 and Batch 4 of the final phase are representative of cement to flyash ratios of 1/3.34 and 1/1.2, respectively. These two batches also passed all the LDR criteria and engineering criteria associated with the final phase of testing.

Based on the successful testing of the solidified material prepared using cement to flyash ratios that varied from 1/1.2 to 1/3.34, it is apparent that the performance of the CSS binder system, and the certification of the final product, is not extremely sensitive to the ratio of these additives. The ratio of cement to flyash of 1/2 can be considered as a goal and not as a absolute requirement for certification of the final product.

Because most of the testing in the final phase was centered upon developing a range for the water to pozzolan ratio, little emphasis was placed on developing a large range for the cement to flyash ratio. The majority of the testing done in the final phase of the treatability study was conducted at a cement to flyash ratio of 1 to 2.

Pond 207C and Clarifier

The batches prepared with the combined waste streams of the clarifier and Pond 207C were conducted at ratios of cement to flyash of 1/2, 1/1, and 1/0. Batches 1C to 3C were prepared with 12.9 percent total solids by weight. Batches 4C to 14C were prepared with 49 percent total solids by weight. These ratios correspond to a TSS loading of 4.2% and 5.7% contributed by the clarifier. Therefore, the maximum amount of solids that can be blended with Pond 207C material during remediation is 5.7%.

The testing of combined Pond 207C and clarifier waste also indicated that passing the acceptance criteria is not extremely sensitive to the cement to flyash ratio. A ratio of one part cement to two parts flyash is selected, with an acceptable range varying from 1/0 to 1/2.

3.2.1.2 Hydrated Lime Addition

<u>Pond 207C</u>

An additional criteria for the blended pozzolans is the addition of lime in the blend. This is important from the standpoint of passing the LDR criteria for the TCLP extract. Lime is used in the CSS formula to provide sufficient amounts of alkalinity to lower the solubility of the metals of concern. The solubility of many metals will remain low when the pH of the solution is alkaline, which results in successfully passing the LDR criteria. Although there are some metals which are amphoteric (solubility increases under acidic or alkaline conditions) such as arsenic, cadmium, chromium, lead, and zinc, no problems have been observed by maintaining sufficient amounts of alkalinity to maintain a pH of 9.0 to 12.0 in the TCLP extract.

In the preliminary testing of the CSS formulation, a fixed amount of lime was added to the waste regardless of the amount of cement and flyash added. Testing in this manner resulted in lime addition varying from 0.5 to 0.7 percent by weight of the solidified product, or a cement/flyash/lime ratio of 1/1.2/0.027 to 1/3.34/0.045. After the addition of lime to the raw waste the pH of the mix was in a range of 11.5 to 12.

In the final phase of testing, lime was added at a fixed dosage for Batches 1 through 5. For these batches the lime dosage was increased, which resulted in a range of 1.1 to 1.4 percent by weight of the total solidified product. The corresponding ratio of cement/flyash/lime varied from 1/1.2/0.05 to 1/3.34/0.09.

The lime dosage for Batches 6 through 24 was based on 1.4 percent by weight of the solidified product. The ratio of cement/flyash/lime varied from 1/2/0.065 to 1/2/0.084.

The selected ratio for cement/flyash/lime to be used during remediation is 1/2/0.075. For lime, the dosage is the approximate average of 0.065 and 0.084. As with the ratio of cement to flyash, the ratio of cement/flyash/lime of 1/2/0.075 is a goal and not an absolute criteria for certification of the final waste form. The range of successful testing in the final treatability phase varied between 1/1.2/0.05 to 1/3.34/0.09. Additionally, the preliminary testing indicated that ratios of cement to lime as low as 0.027 successfully passed the TCLP LDR criteria.

Pond 207C and Clarifier

The ratios of cement/flyash/lime that were tested for the clarifier and 207C ranged between 1/2/0.066 and 1/2/0.077. All of these ratios successfully passed the TCLP LDR requirements. For remediation, a blend of 1/2/0.075 will be the goal.

3.2.2 Water to Pozzolan Ratio

The criteria determined to be the most critical for successful certification of the final waste form is the water to pozzolan ratio. This ratio is determined by analyzing the waste stream for total solids by gravimetric methods to obtain a total water content. The weight of the water for a given quantity of waste is then divided by the total quantity of pozzolans added to the waste stream. The resulting number is the water to pozzolan ratio.

For the purpose of testing during the treatability study, pozzolan was defined as cement plus flyash. However, during remediation the lime will be blended with the cement and flyash. The pozzolan calculation will require adjustment to subtract out the lime portion of the pozzolan blend to achieve the proper ratio in the field.

Pond 207C

The preliminary testing conducted for 207C tested water to pozzolan ratios that varied from approximately 0.38 to 0.64.

Several batches in the final phase of the treatability study for Pond 207C evaluated water to pozzolan ratios which varied from 0.34 to 0.56. However, only Batch 5 was tested at a water to pozzolan ratio of 0.56. This batch successfully passed all of the certification criteria and the wet/dry and freeze/thaw durability testing. Water to pozzolan ratios which successfully passed all to the certification criteria and the durability testing include 0.34, 0.36, 0.42, 0.44, 0.46, and 0.56.

The bulk of the final phase testing was done at water to pozzolan ratios varying from 0.34 to 0.50. These ratios were used for Pond 207C and the combined waste stream of the clarifier and Pond 207C. The upper limit was lowered from 0.56 to 0.50 to ensure that all of the LDR criteria and the engineering criteria were successfully passed, especially the durability testing.

Pond 207C and Clarifier

The preliminary tests for the clarifier were conducted at water to pozzolan ratios that ranged from 0.69 to 0.99. None of these water to pozzolan ratios were successful in passing the durability tests. These ranges are relatively high and likely contributed to the failures in the durability testing (See Attachment A-3).

The final phase of testing was conducted at water to pozzolan ratios that varied from 0.34 to 0.50. These ratios successfully passed all acceptance criteria and performed acceptably in the durability testing. Specific information concerning durability testing can be found in Section 3.1.2.2.

3.2.3 Waste Loading

The waste loadings tested during the treatability study did not affect compliance with LDR criteria. All loadings tested successfully passed LDR criteria in the TCLP extract. The waste loading parameters include total solids, total dissolved solids, total suspended solids, and the concentration of the chemicals of concern in the raw waste.

The waste loading appears to have an effect on the durability testing. At high total solid concentrations (49%) and a high water to pozzolan ration (0.50), the durability test cylinders failed. However, the solids concentration tested is relatively high compared to what is expected for actual conditions during remediation. The waste loading parameters, with the exception of individual contaminant concentrations, will therefore, have an upper limit not to exceed for the operating range, since testing has not been conducted to determine at what higher levels these parameters might cause failure for the certification criteria.

The concentrations of the LDR constituents in the waste stream should not leach above their respective LDR criteria as long sufficient alkalinity is provided by the addition of lime. The concentration of volatile and semivolatile organics have been determined to be lower than the LDR criteria in the raw waste by the Pond Sludge and Clarifier Waste Characterization Report (HALLIBURTON NUS, January 1992) and therefore should not present any concerns. All of the analytical data from the treatability study are provided in Section 3.1 and indicate that there are no concerns regarding passing the LDR criteria.

Pond 207C

The range of total solids, dissolved solids, and suspended solids that were tested for Pond 207C are provided in Table 3-21.

TABLE 3-21

WASTE LOADINGS FOR POND 207C

Total Solids (Percent)	Total Dissolved Solids (Percent)	Total Suspended Solids (Percent)
40.0	27.3	9.3
38.6	34.1	0.89
35.0	33.1	7.4
38.6	34.96	9.1
44.0	40.4	9.1
43.4	32.1	11.3
49.1	31.9	17.2

As discussed in Section 2.3.1, the total suspended solids (TSS) plus the total dissolved solids (TDS) does not always equal the total solids (TS). This could be a result of analytical accuracy, or overlap of solids in both TSS and TDS (i.e., some solids may be recorded as both TSS and TDS). It should be noted that the water to pozzolan ratios were based on the total solids value. The value used for total solids is typically based on the average of duplicate or triplicate analyses.

For Pond 207C, the total solids varied from 35 to 49.1 percent. Because the majority of the total solids is comprised of dissolved solids, the 207C slurries were always flowable slurries, not sludge cakes. The TDS varied from 27.3 to 34.96 percent at ambient temperatures. A value of 40.4 percent TDS was achieved by heating the 207C slurry to 70°F, which resulted in additional crystals going into solution. This testing was done to provide an elevated TDS loading.

The remaining TDS values for Pond 207C varied from 27.3 to 34.96 percent. The value of 27.3 is from testing that was conducted in February, whereas the other values correspond to testing conducted in April. The TDS values of 34.1%, 33.1%, 34.96%, 32.1%, and 31.9% are all essentially the same value. The pond material was all from the same sample, which was at the same approximate temperature when samples were collected. The slurry in all of the cases was saturated at the given room temperature, which was approximately 62°F to 65°F.(slurries were believed to be saturated because excess crystal was present). The variation between 32 and 35 percent is relatively small and is probably related to analytical precision.

The TSS varied from 3.1 to 17.2 percent, depending on the quantity of silty sludge that was added to the slurry. Based on the current volumes of material in Pond 207C, the estimated TSS of the homogenized pond is between 5 and 10 percent. Thus, the range of TSS values tested brackets the expected operating conditions.

<u>Pond 207C and the Clarifier</u>

A summary of the range of total solids, total dissolved solids, and suspended solids that were tested for Pond 207C combined with the clarifier are provided in Table 3-22.

TABLE 3-22

SUMMARY OF WASTE LOADING PARAMETERS FOR POND 207C COMBINED WITH THE CLARIFIER

Total Solids (Percent)	Total Dissolved Solids (Percent)	Total Suspended Solids (Percent)
33.8	27.7	11.0
38.9	34.6	11.6

The TSS values for the clarifier combined with Pond 207C slurry show little variation. The clarifier was combined with a 207C slurry that had approximately 5 percent TSS. The clarifier waste stream had a TSS concentration of 5.7 percent, which is considered the maximum TSS loading which can be accepted from the clarifier.

3.3 PROCESS FORMULATION DEVELOPMENT (LIME/CEMENT/FLYASH/LATEX)

This section provides the process formulation development for lime/cement/flyash/latex. The treatability study was designed to compare formulations of lime/cement/flyash to similar formulations of lime/cement/flyash/latex. This was done so comparisons could be made to evaluate the effect of Latex 2000 on the final product. For that reason, most of the process formulation parameters are identical to those presented in Section 3.2.

3.3.1 <u>CSS Binder Formulation</u>

3.3.1.1 Latex 2000 Dosage

<u>Pond 207C</u>

The Latex 2000 System consists of 3 components; Latex, D-Air-3, and Stabilizer 434B. These components must be added to the waste stream in a specified order. The order of addition is D-Air-3, then Stabilizer 434B, followed by the Latex. The dosage of Latex 2000 was varied from 1 to 5 percent by weight of the cement. The dosage of D-Air-3 is at 4 percent by weight of the Latex, and the Stabilizer 434B dosage is 15 percent by weight of the Latex.

<u>Pond 207C and Clarifier</u>

The dosages used for Latex, D-Air-3, and Stabilizer 434B are identical to those mentioned above for Pond 207C.

3.3.1.2 Cement to Flyash Ratio

<u>Pond 207C</u>

The cement to flyash ratios tested with latex were identical to those tested without the latex additive. The values for the cement to flyash ratio varied from 1/1.2 to 1/3.4. As was the case in Section 3.2.1.1, the cement to flyash ratio of 1/2 should be considered a goal and not an absolute requirement.

<u>Pond 207C and Clarifier</u>

The cement to flyash ratio tested with the latex additive was 1/2. This was the lonly ratio tested.

3.3.1.3 Hydrated Lime Addition

<u>Pond 207C</u>

The addition of lime is important from the standpoint of passing the LDR criteria for the TCLP extract. Lime is used in the CSS formula to provide sufficient amounts of alkalinity to adjust the pH of the TCLP extract. The solubility of many metals will remain low when the pH of the solution is alkaline, which results in successfully passing the LDR criteria. The exception are amphoteric metals such as arsenic, cadmium, chromium, lead, and zinc, which demonstrate increased solubility at both acidic and alkaline conditions.

In the final phase of testing, a fixed amount of lime based on data from Phase I/II testing, was added for Batches 1L through 9L. For these batches, the lime dosage was also increased, which resulted in a range of 1.1 to 1.4 percent by weight of the total solidified product. The corresponding ratio of cement/flyash/lime varied from 1/1.2/0.05 to 1/3.34/0.09.

The lime dosage for Batches 10L through 19L was based on 1.4 percent by weight of the solidified product. The ratio of cement/flyash/lime varied from 1/2/0.065 to 1/2/0.084.

The selected ratio for cement/flyash/lime to be used during remediation is 1/2/0.075. For lime, the dosage is the approximate average of 0.065 and 0.084. As with the ratio of cement to flyash, the ratio of cement/flyash/lime of 1/2/0.075 is a goal and not an absolute criteria for certification of the final waste form. The range of successful testing in the final treatability phase varied between 1/1.2/0.05 to 1/3.34/0.09. Additionally, the preliminary testing indicated that ratios of cement to lime as low as 0.027 successfully passed the TCLP LDR criteria.

Pond 207C and Clarifier

The lime dosage for these mixes was held constant at 1.4 percent of the total weight of the end product. This resulted in the cement/flyash/lime dosage ranging from 1/2/0.066 to 1/2/0.078. The selected ratio for the combined waste stream of Pond 207C and the Clarifier with Latex 2000 is 1/2/0.072.

3.3.2 **Water to Pozzolan Ratio**

Pond 207C

The water to pozzolan ratios tested for Pond 207C with latex are the same as Pond 207C without latex. The water to pozzolan ratio varied from 0.34 to 0.56.

Pond 207C and Clarifier

The water to pozzolan ratios tested for the combined waste stream of Pond 207C and the Clarifier varied from 0.34 to 0.50.

3.3.3 Waste Loading

Pond 207C

The waste loadings tested for Pond 207C using Latex 2000 were similar to those without the Latex 2000 System and are summarized in Table 3-23.

TABLE 3-23

WASTE LOADINGS FOR POND 207C

Total Solids (Percent)	Total Dissolved Solids (Percent)	Total Suspended Solids (Percent)
40.0	27.3	9.3
35.0	33.1	7.4
38.6	34.96	9.1
43.4	32.1	11.3
49.1	31.9	17.2

Pond 207C and Clarifier

The waste loading for the combined waste stream of Pond 207C and the Clarifier was as follows:

- Total Solids = 38.9 percent
- Total Dissolved Solids = 34.6 percent
- Total Suspended Solids = 11.6 percent

3.4 PROCESS FORMULATION

This section provides the process formulation for the remediation of Pond 207C and the Clarifier. Included in the process formulation are the specified pozzolan blend and the operating envelope. Based on the treatability study testing conducted in the laboratory, adherence to the process formulation during remediation should result in compliance with all certification criteria. These criteria include RCRA regulations for the characteristic of toxicity (40 CFR

261.24) and the Land Disposal Restrictions (40 CFR 268 Subpart C and D) for listed wastes F001-003, F005-007, and F009. Also included in the certification criteria are testing to verify that there are no free liquids present in the final waste form (Paint Filter Liquids Test, SW-9095) and testing to determine if the solidified material is a solid (Standard Test Method for Determining Whether a Material is a Liquid or a Solid, ASTM D4359-84).

Additionally, adherence to the process formulation should also result in a final product which is capable of passing durability testing and having acceptable unconfined compressive strengths (in excess of 50 psi). The durability testing includes Standard Test Methods for Freezing and Thawing Compacted Soil-Cement Mixtures (ASTM D569-89) and the Standard Test Methods for Wetting and Drying Compacted Soil-Cement Mixtures (ASTM D559-89).

3.4.1 CSS Binder Formulation

3.4.1.1 Lime/Cement/Flyash

The process formulation as developed in the laboratory for the blending of pozzolan material is applicable for Pond 207C waste and for the combined waste stream of the clarifier and Pond 207C. The pozzolan blend includes Type V portland cement as specified by ASTM C-150 and Type C flyash as specified by ASTM C-618. The pozzolan blend also includes high calcium hydrated lime (industrial grade). The pozzolan blend is provided in Table 3-24.

TABLE 3-24

POZZOLAN BLEND FORMULA

Waste Stream	Desired CSS Binder Formulation Cement/Flyash/Lime	Acceptable Range for CSS Binder Formulation Cement/Flyash/Lime
Pond 207C	1/2/0.075	1/1.2/0.05 to 1/3.34/0.09
Pond 207C and Clarifier	1/2/0.075	1/0/0.022 to 1/2/0.077

3.4.1.2 Lime/Cement/Flyash Plus The Latex 2000 System

The pozzolan blend includes Type V portland cement as specified by ASTM C-150 and Type C flyash as specified by ASTM C-618. The pozzolan blend also includes high calcium hydrated lime (industrial grade). The pozzolan blend is provided Table 3-25.

TABLE 3-25

POZZOLAN BLEND FORMULA

Waste Stream	Desired CSS Binder Formulation Cement/Flyash/Lime/Latex	Acceptable Range for CSS Binder Formulation Cement/Flyash/Lime/Latex
Pond 207C	1/2/0.075/0.03	1/1.2/0.05/0.01 to 1/3.34/0.09/0.05
Pond 207C and Clarifier	1/2/0.072/0.03	1/2/0.066/0.01 to 1/2/0.078/0.05

The Latex 2000 System formulation includes Latex, D-Air-3, and Stabilizer 434B. The same dosages can be used for both Pond 207C and the combined waste stream of Pond 207C and the Clarifier. The Latex dosage is based on a weight percentage of the cement. The desired dosage is 5 percent by weight; however, the dosage can vary from 3 to 5 percent by weight of the cement. The testing conducted for the laboratory did not evaluate various ranges for the dosages of D-Air-3 or Stabilizer 434B. These additives were added at fixed percentages of the Latex. D-Air-3 was added at 4 percent by weight of the Latex, and Stabilizer 434B was added at 15 percent by weight of the Latex.

3.4.2 Operating Envelope (Water/Pozzolan Ratio and Waste Loading)

The operating range consists of the water to pozzolan ratio, which is controlled by the total solids in the waste stream. Additionally, the operating range will include concentrations of total dissolved solids and total suspended solids which should not be exceeded. It should be noted that exceedance of these levels will not automatically result in failure of the certification criteria or the engineering criteria, however laboratory testing has not been conducted at levels above these concentrations to verify success.

3.4.2.1 Operating Envelope for Pond 207C (Lime/Cement/Flyash)

The operating envelope for Pond 207C, as determined by testing in the Laboratory, is based on maximum ranges for total dissolved solids (TDS), total suspended solids (TSS), total solids (TS), and the corresponding water to pozzolan ratios. The relationship between TDS and TSS is shown in Figure 3-1. The TDS and TSS concentrations for Pond 207C must be within the cross-hatched area shown on Figure 3-1, or fresh water must be added to dilute the TDS, or pond water added to dilute the TSS. The water to pozzolan ratio was based on the total solids concentration during the treatability study. However, during remediation, the input specific gravity will be used to control the process (see Section 5.0 for details on process control). The operating ranges for the water to pozzolan ratios vs. TS, TDS, and TSS are shown in Figures 3-2, 3-3, and 3-4, respectively. Review of Figures 3-2 through 3-4 indicate that the water to pozzolan ratio must be between 0.34 and 0.50, but in some cases, 0.56 is acceptable (see section 3-2).

The operating ranges shown in Figures 3-2, 3-3, and 3-4 represent the range of testing conducted in the treatability study that successfully passed all of the LDR criteria and performed in an acceptable fashion in the durability testing. The operating ranges extend from the highest concentrations toward zero, inferring that waste loadings below those tested will successfully pass all criteria. The lower limits would represent wash down water.

3.4.2.2 Operating Range for Pond 207C and the Clarifier (Lime/Cement/Flyash)

The remediation of the clarifier will be conducted by blending the slurried clarifier material with the slurried 207C material. Laboratory testing conducted for the combined waste stream was based on adding the clarifier contents at a maximum of 5.7 percent total suspended solids in the combined slurry. During remediation the amount of clarifier contents added to the 207C slurry will be dependent on the concentration of the TSS in the clarifier slurry such that the maximum concentration of 5.7 percent is not exceeded and the combined stream does not exceed 10 percent TSS. Higher concentrations can not be processed by the RCM.

Once the clarifier contents are blended with the 207C slurry, analysis for TDS and TSS should be conducted to verify that the concentrations are within the operating range shown on Figure 3-5. If the concentration of either parameter

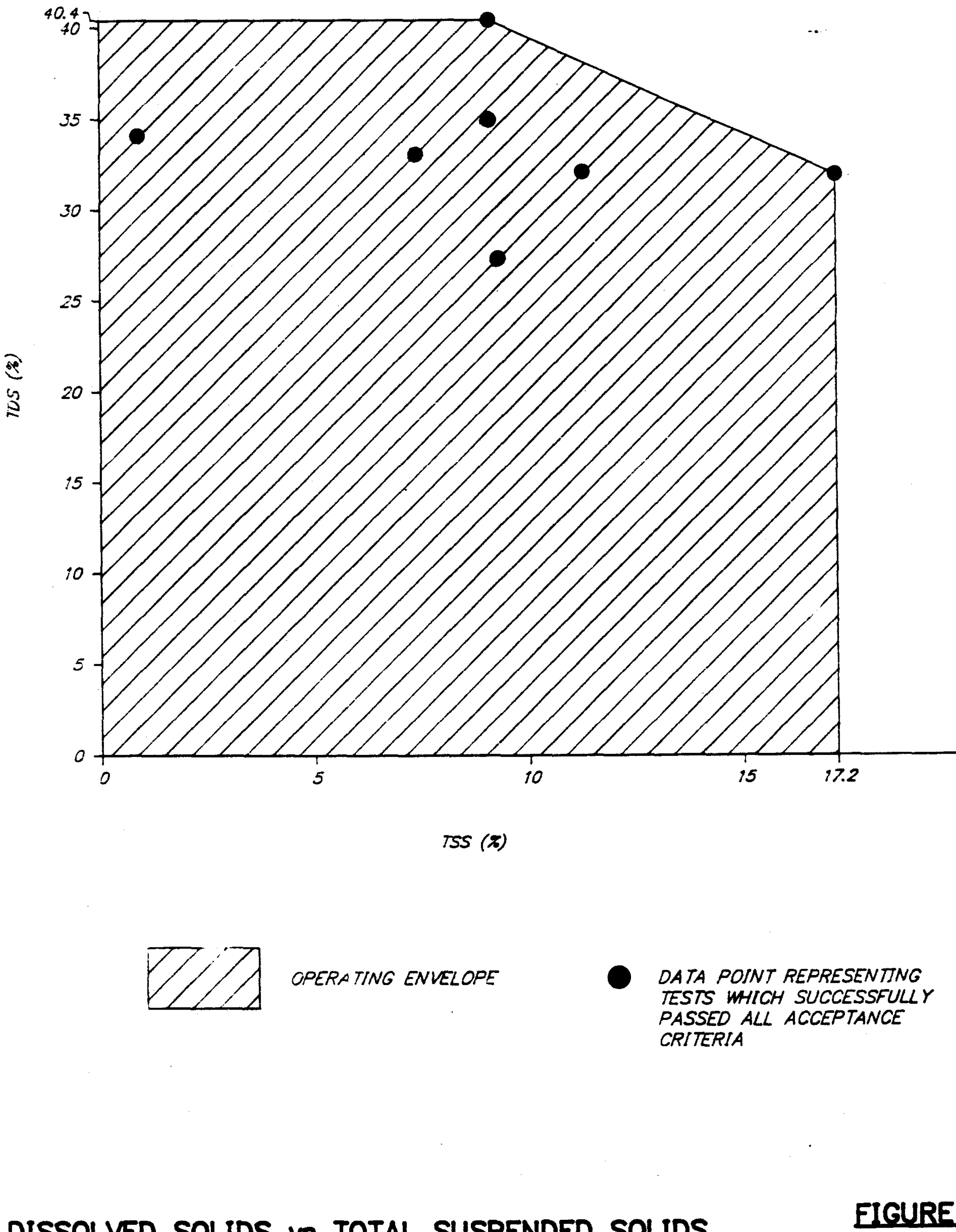

FIGURE 3-1

TOTAL DISSOLVED SOLIDS vs TOTAL SUSPENDED SOLIDS
POND 207C
LIME/CEMENT/FLYASH
ROCKY FLATS, GOLDEN, COLORADO

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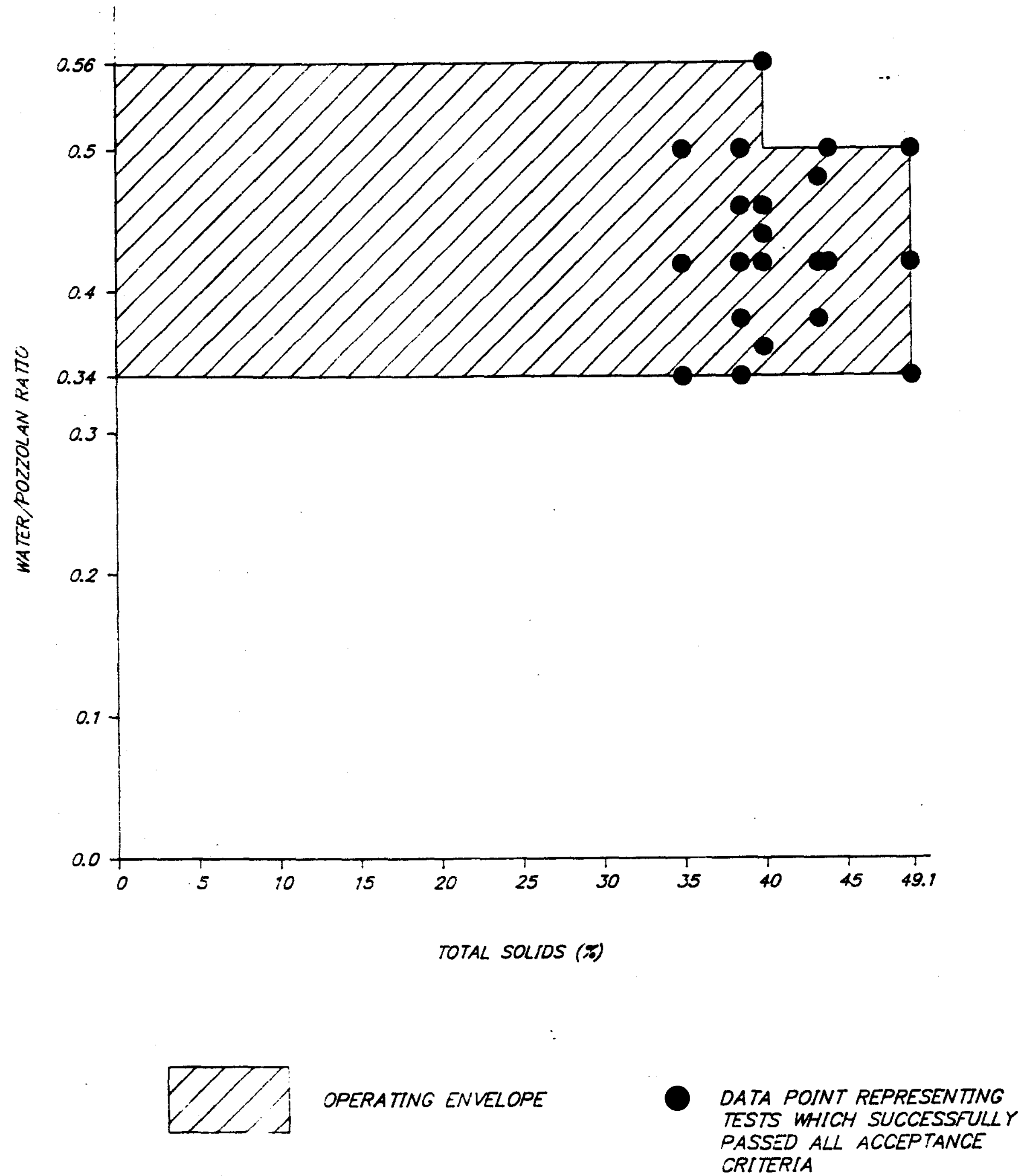

FIGURE 3-2

WATER TO POZZOLAN RATIO vs TOTAL SOLIDS
POND 207C
LIME/CEMENT/FLYASH
ROCKY FLATS, GOLDEN, COLORADO

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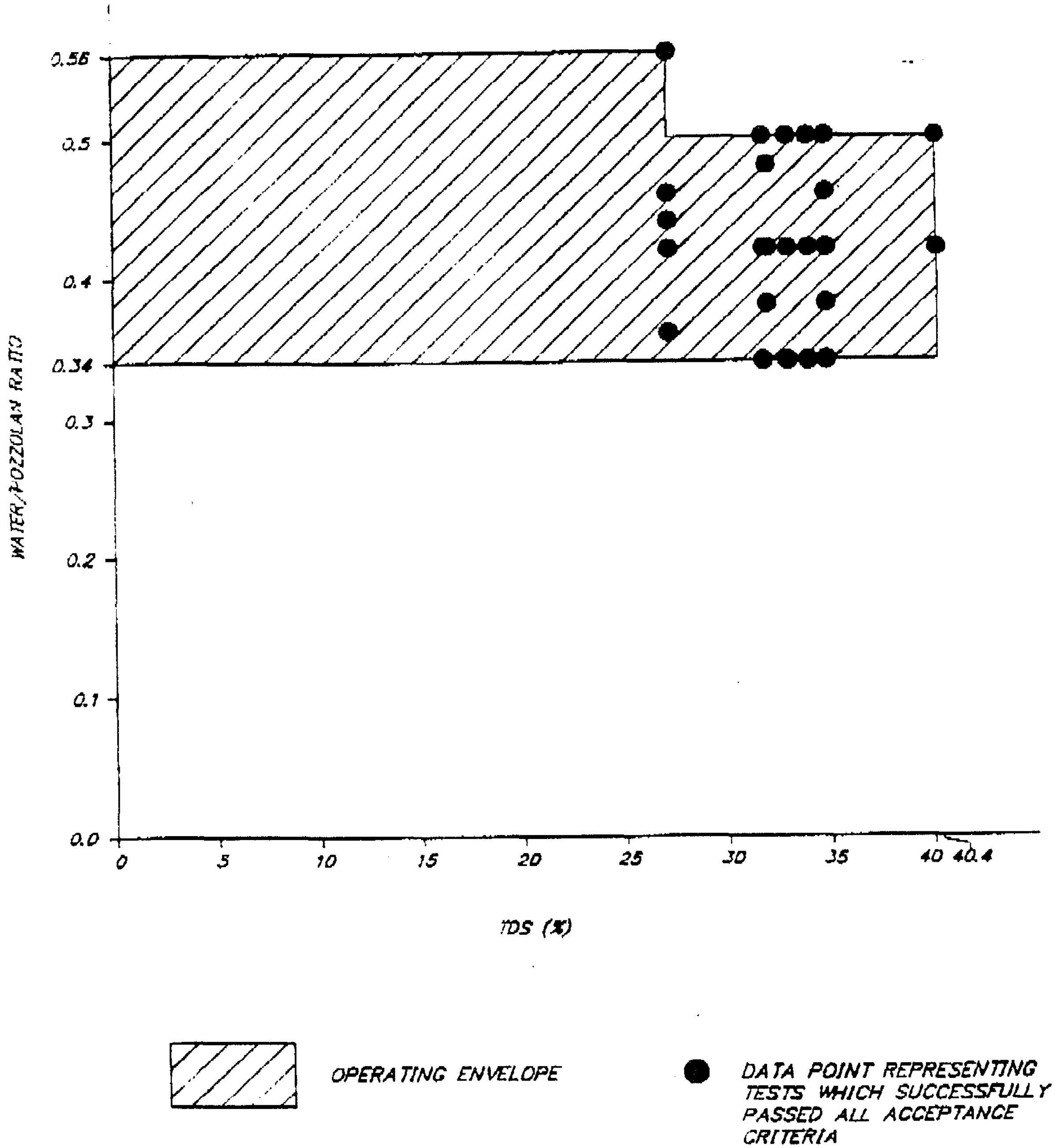

FIGURE 3-3

WATER TO POZZOLAN RATIO vs TOTAL DISSOLVED SOLIDS
POND 207C
LIME/CEMENT/FLYASH
ROCKY FLATS, GOLDEN, COLORADO

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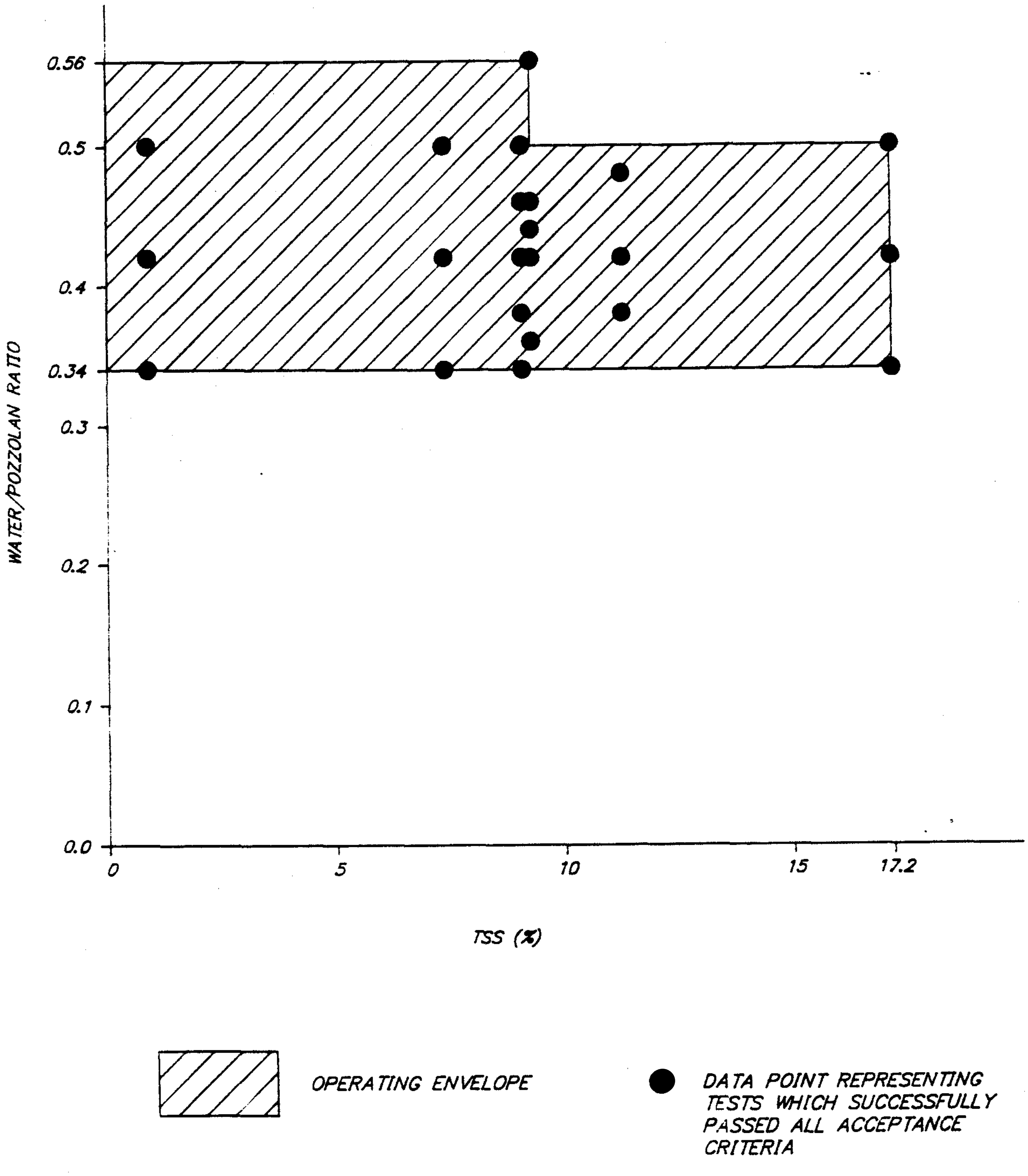

FIGURE 3-4

WATER TO POZZOLAN RATIO vs TOTAL SUSPENDED SOLIDS
POND 207C
LIME/CEMENT/FLYASH
ROCKY FLATS, GOLDEN, COLORADO

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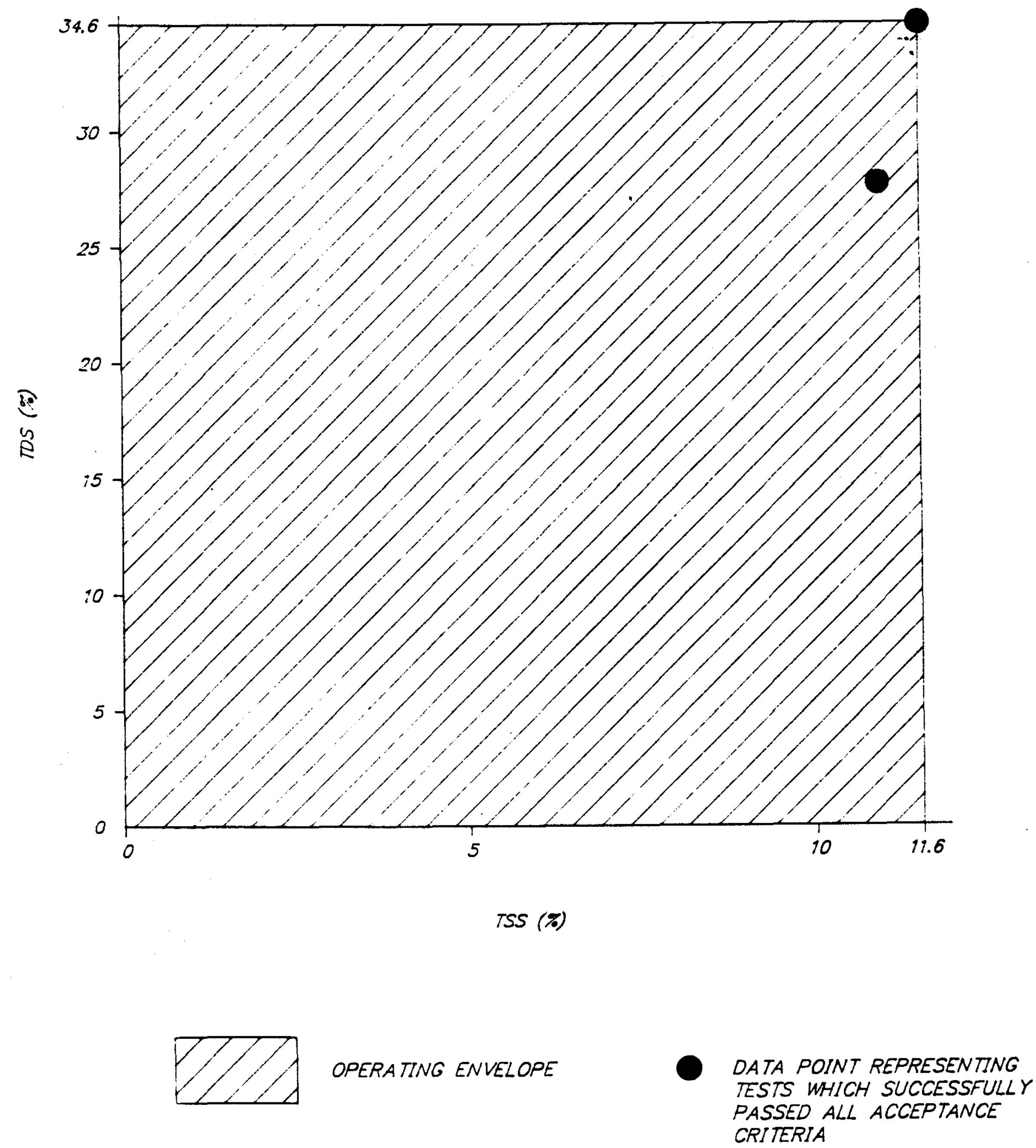

FIGURE 3-5

TOTAL DISSOLVED SOLIDS vs TOTAL SUSPENDED SOLIDS
POND 207C AND CLARIFIER
LIME/CEMENT/FLYASH
ROCKY FLATS, GOLDEN, COLORADO

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exceeds the range on Figure 3-5, then dilution water should be added to reduce the concentration to within the operating range.

As for Pond 207C, the combined input slurry specific gravity will be determined to control the process (see Section 5.0 for additional details). Operating ranges for total solids, total dissolved solids, and total suspended solids vs. water to pozzolan ratios are shown on Figures 3-6, 3-7, and 3-8, respectively. These figures indicate that the acceptable water to pozzolan ratio varies between 0.34 and 0.50, while the waste loading operating ranges for TDS, TSS, and TS vary between 0-34.6%, 0-11.6%, and 0-38.9%, respectively. Also, Figure 3-8 indicates that the maximum TSS concentration from the clarifier is 5.7 percent.

3.4.2.3 Operating Range for Pond 207C (Lime/Cement/Flyash Plus Latex 2000)

The treatability testing for Pond 207C using the Latex 2000 System was conducted in a similar manner as that described in Section 3.4.2.1. The operating range for TDS and TSS is shown on Figure 3-9. The operating ranges for the water to pozzolan ratios vs. TS, TDS, and TSS are shown in Figures 3-10, 3-11, and 3-12, respectively.

3.4.2.4 Operating Range for Pond 207C and the Clarifier (Lime/Cement/Flyash Plus Latex 2000)

The treatability testing for Pond 207C and the Clarifier using the Latex 2000 System was conducted in a similar manner as that described in Section 3.4.2.2. The operating range for TDS and TSS is shown on Figure 3-13. The operating ranges for the water to pozzolan ratios vs. TS, TDS, and TSS are shown in Figures 3-14, 3-15, and 3-16, respectively.

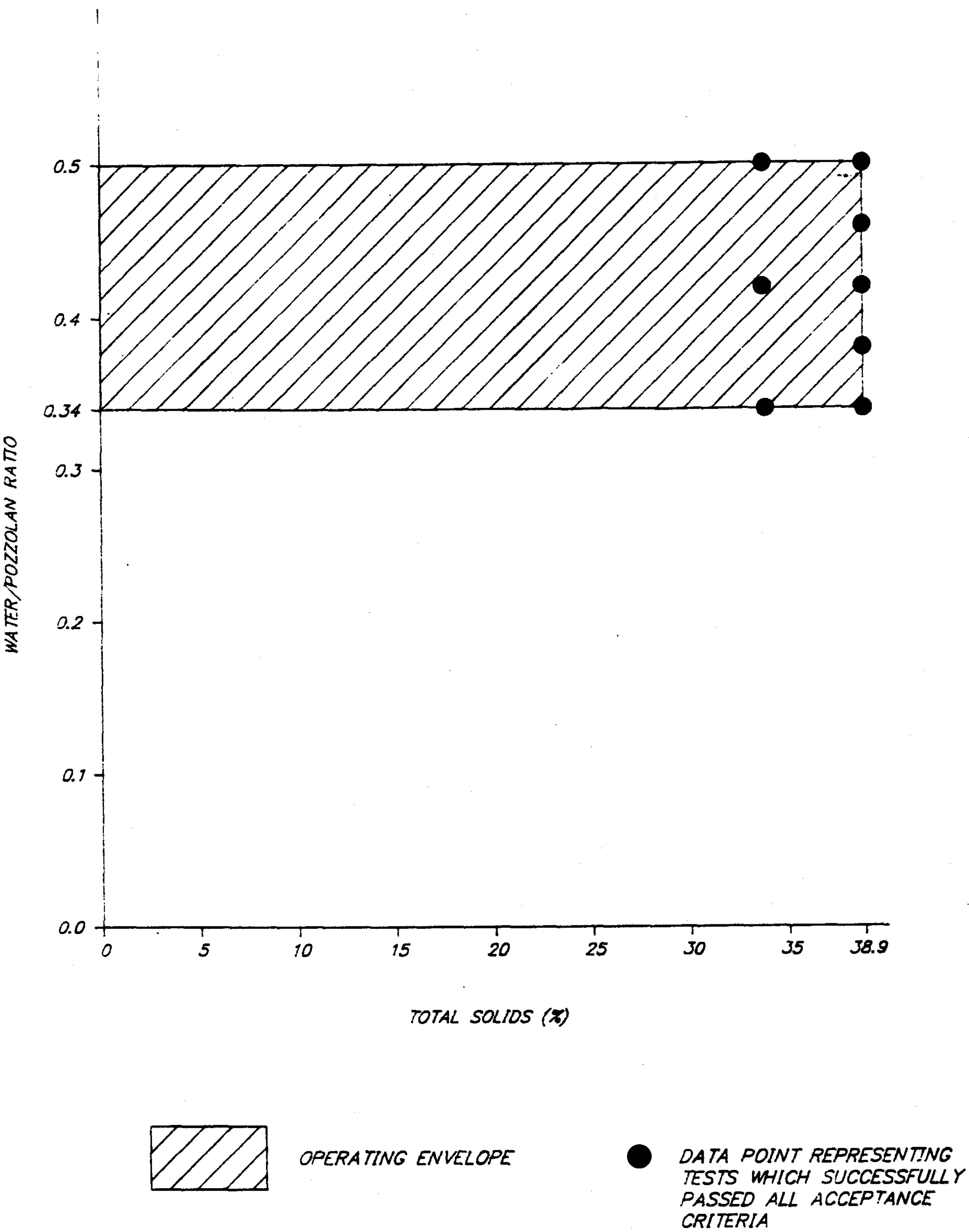

FIGURE 3-6

WATER TO POZZOLAN RATIO vs TOTAL SOLIDS
POND 207C AND CLARIFIER
LIME/CEMENT/FLYASH
ROCKY FLATS, GOLDEN, COLORADO

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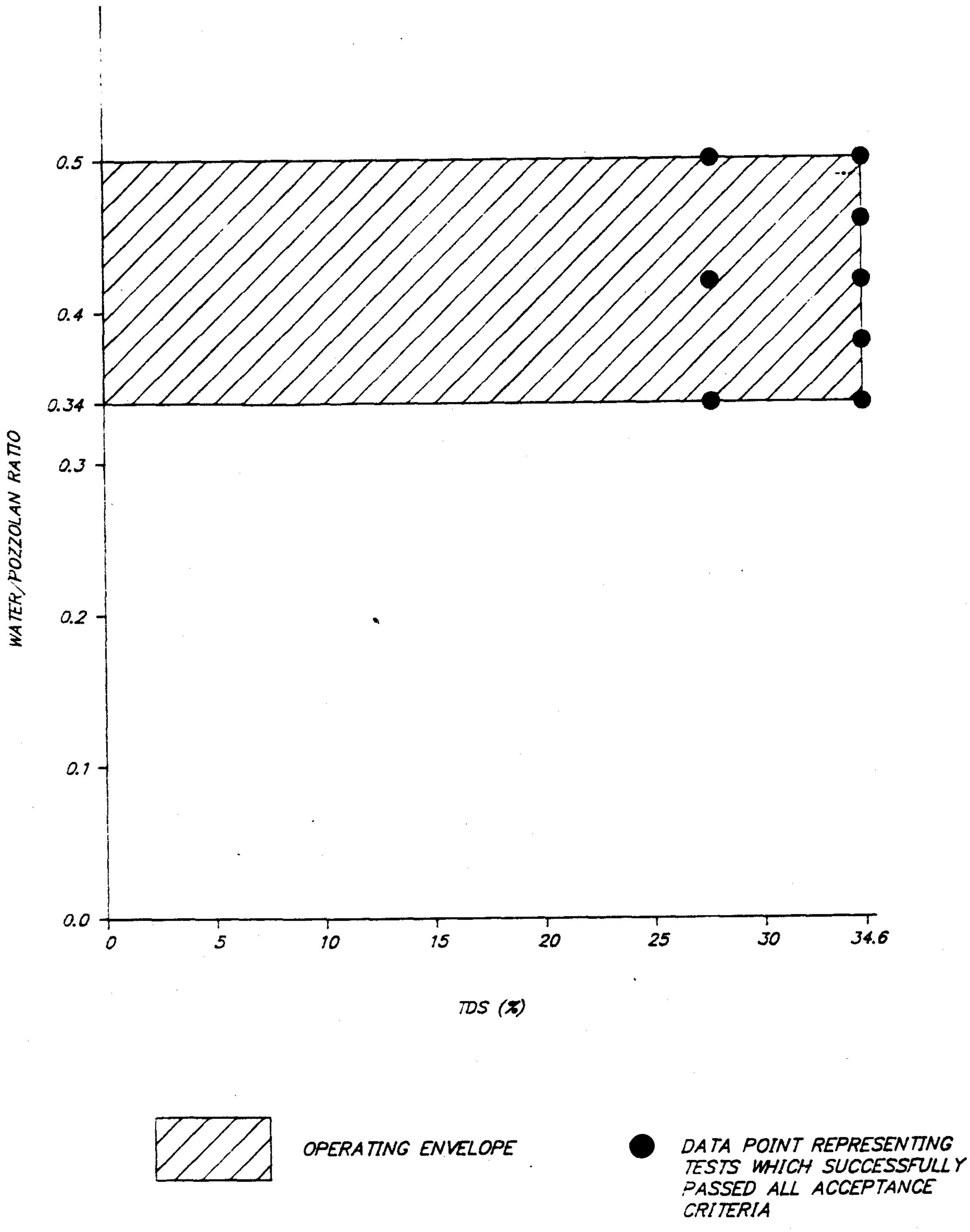

FIGURE 3-7

WATER TO POZZOLAN RATIO vs TOTAL DISSOLVED SOLIDS
POND 207C AND CLARIFIER
LIME/CEMENT/FLYASH
ROCKY FLATS, GOLDEN, COLORADO

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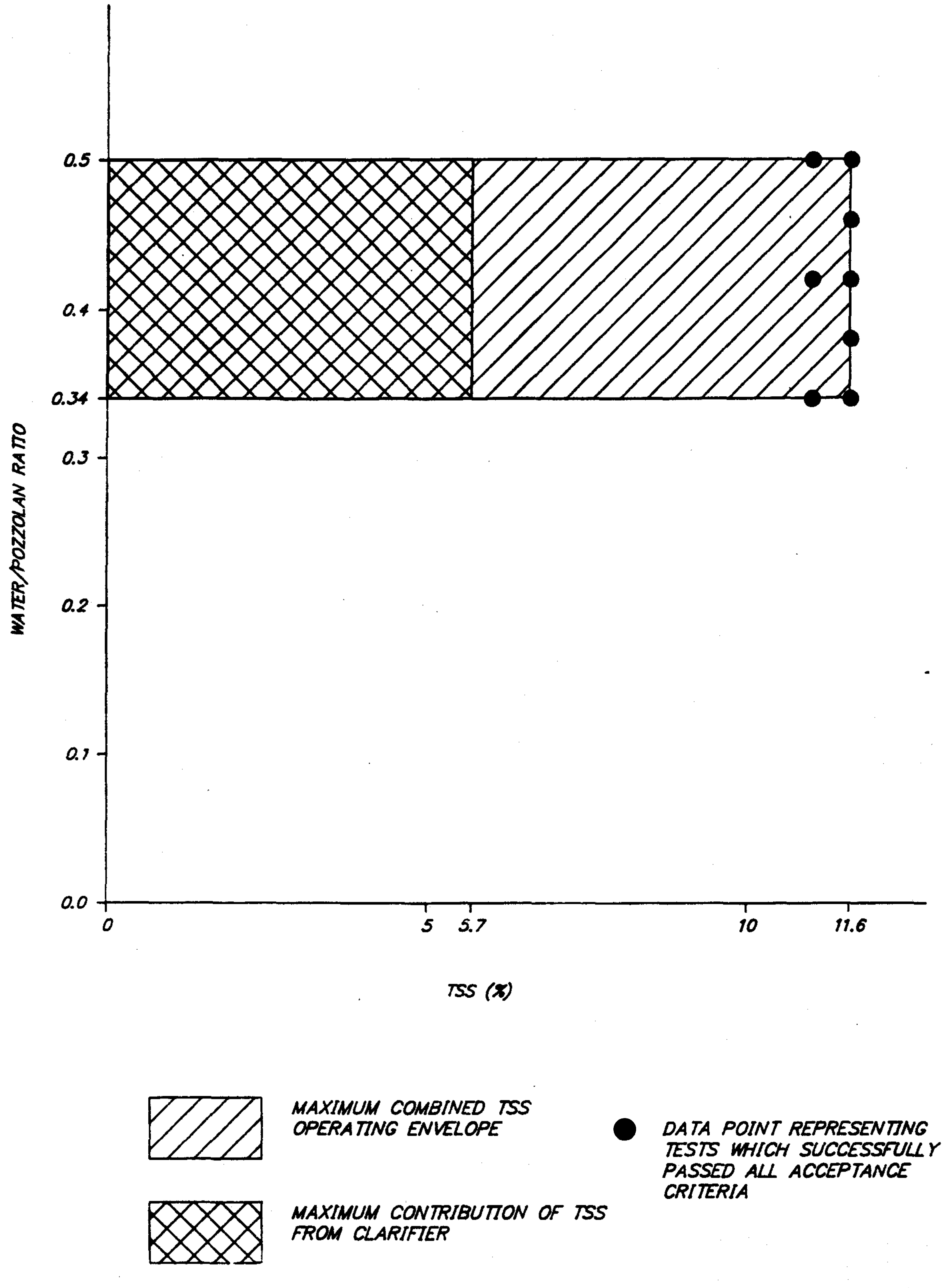

FIGURE 3-8

WATER TO POZZOLAN RATIO vs TOTAL SUSPENDED SOLIDS
POND 207C AND CLARIFIER
LIME/CEMENT/FLYASH
ROCKY FLATS, GOLDEN, COLORADO

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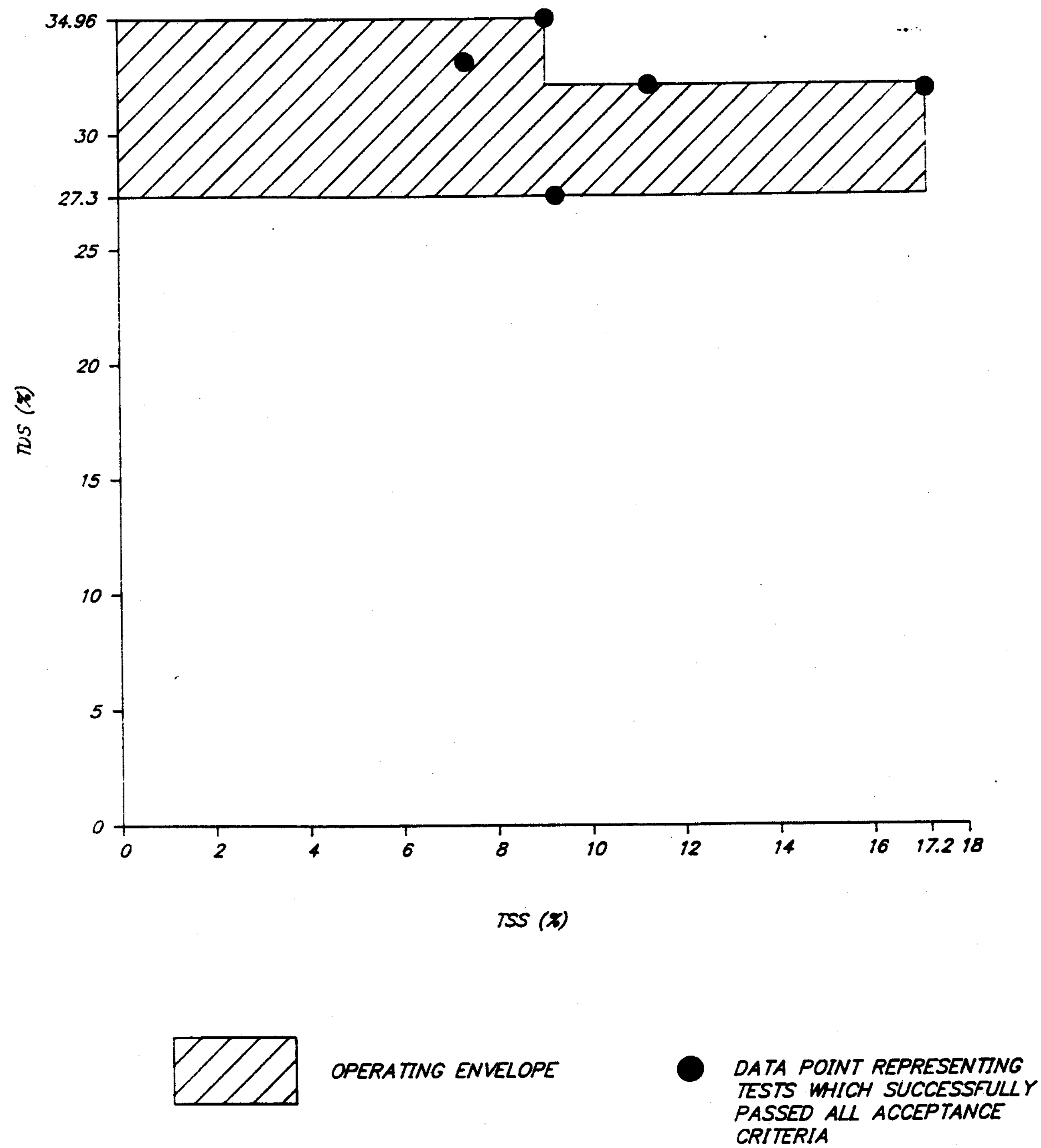

FIGURE 3-9

TOTAL DISSOLVED SOLIDS vs TOTAL SUSPENDED SOLIDS
POND 207C
LIME/CEMENT/FLYASH/LATEX
ROCKY FLATS, GOLDEN, COLORADO

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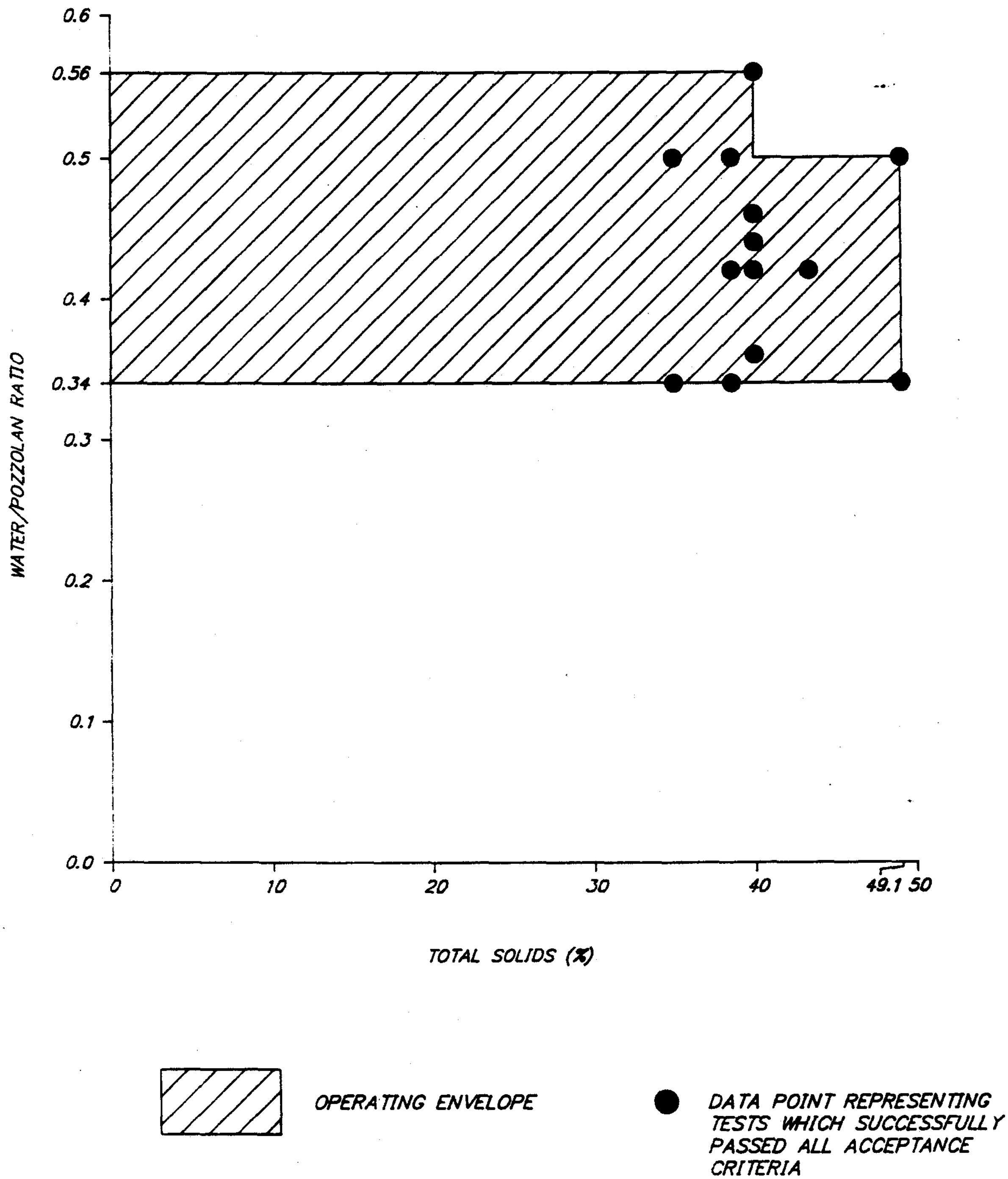

FIGURE 3-10

WATER TO POZZOLAN RATIO vs TOTAL SOLIDS
POND 207C
LIME/CEMENT/FLYASH/LATEX
ROCKY FLATS, GOLDEN, COLORADO

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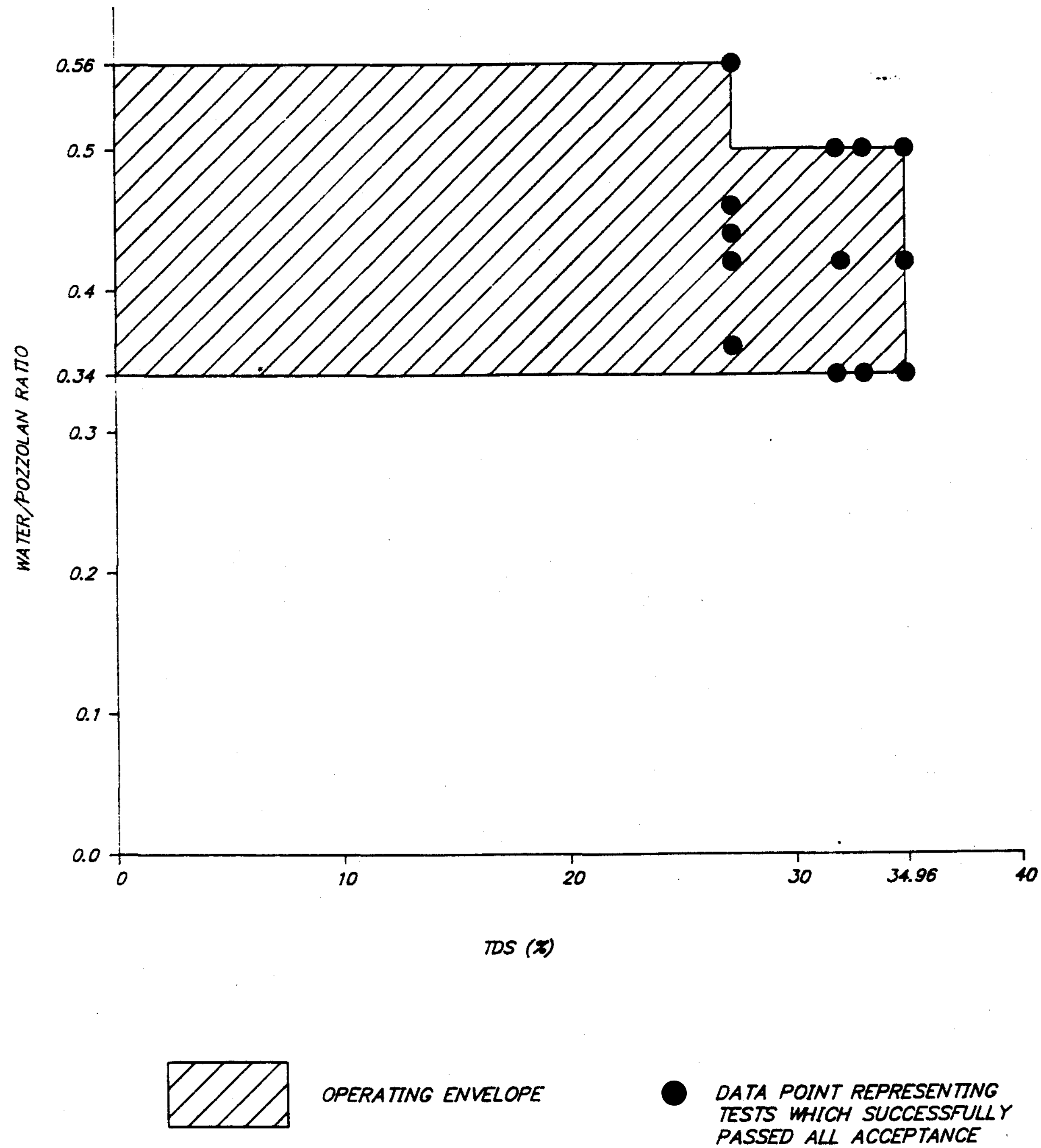

FIGURE 3-11

WATER TO POZZOLAN RATIO vs TOTAL DISSOLVED SOLIDS
POND 207C
LIME/CEMENT/FLYASH/LATEX
ROCKY FLATS, GOLDEN, COLORADO

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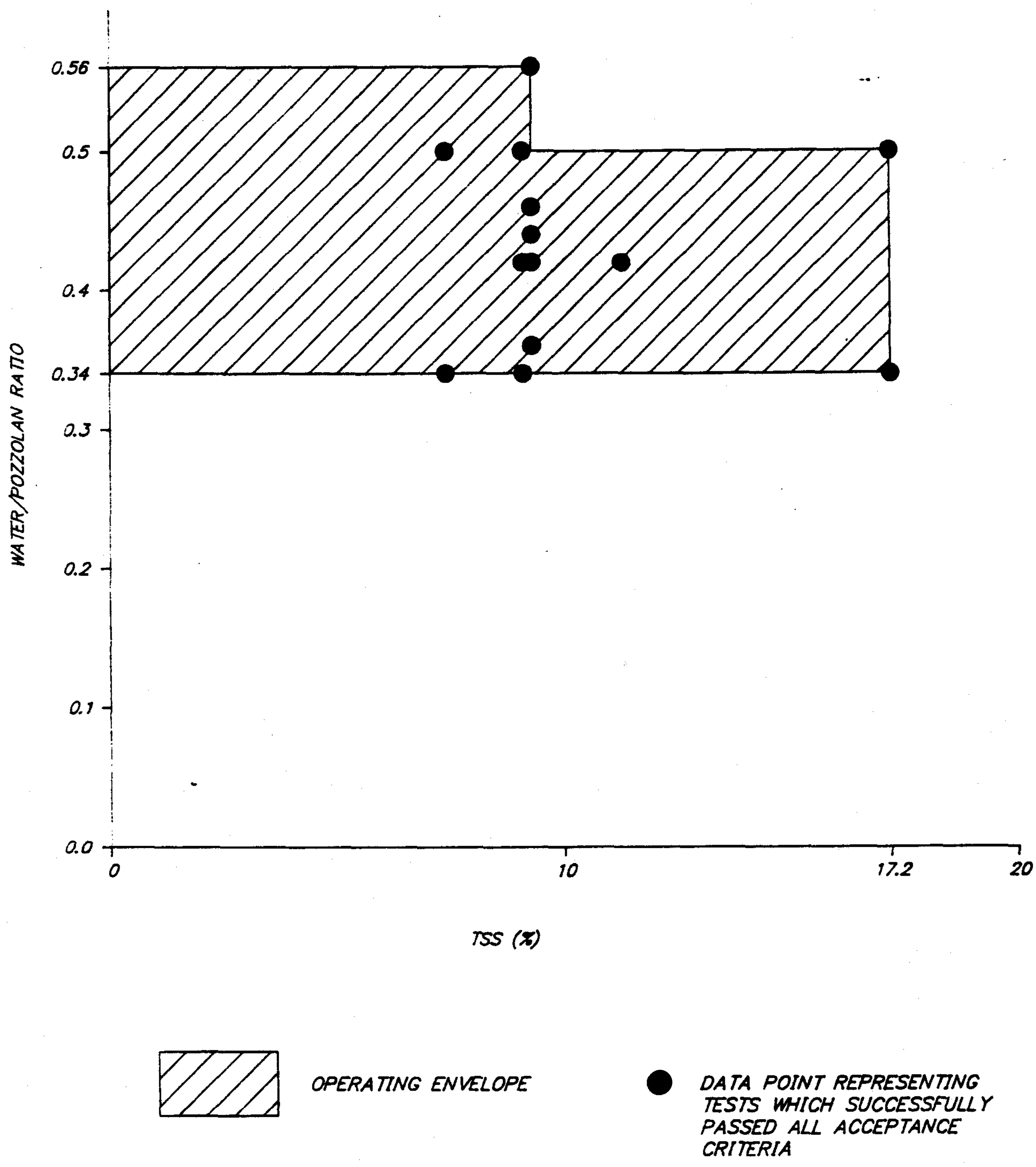

FIGURE 3–12

WATER TO POZZOLAN RATIO vs TOTAL SUSPENDED SOLIDS
POND 207C
LIME/CEMENT/FLYASH/LATEX
ROCKY FLATS, GOLDEN, COLORADO

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Telecopy No: 303-469-6354 **Page** 1 **of** 5
(Including Cover Page)

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3-15 →	3-80
3-16 →	3-81

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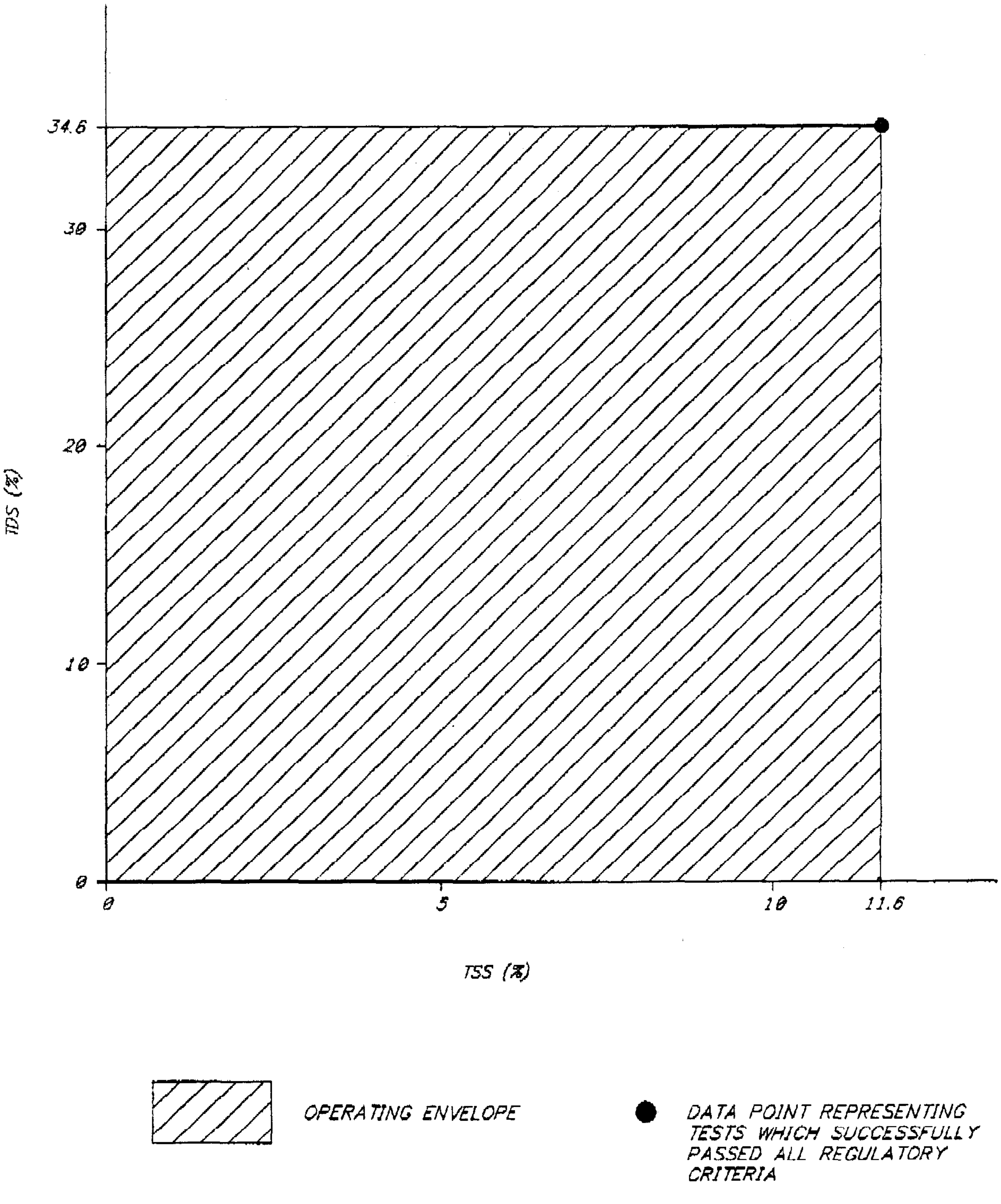

FIGURE 3-13

TOTAL DISSOLVED SOLIDS vs TOTAL SUSPENDED SOLIDS
POND 207C AND CLARIFIER
LIME/CEMENT/FLYASH/LATEX
ROCKY FLATS, GOLDEN, COLORADO

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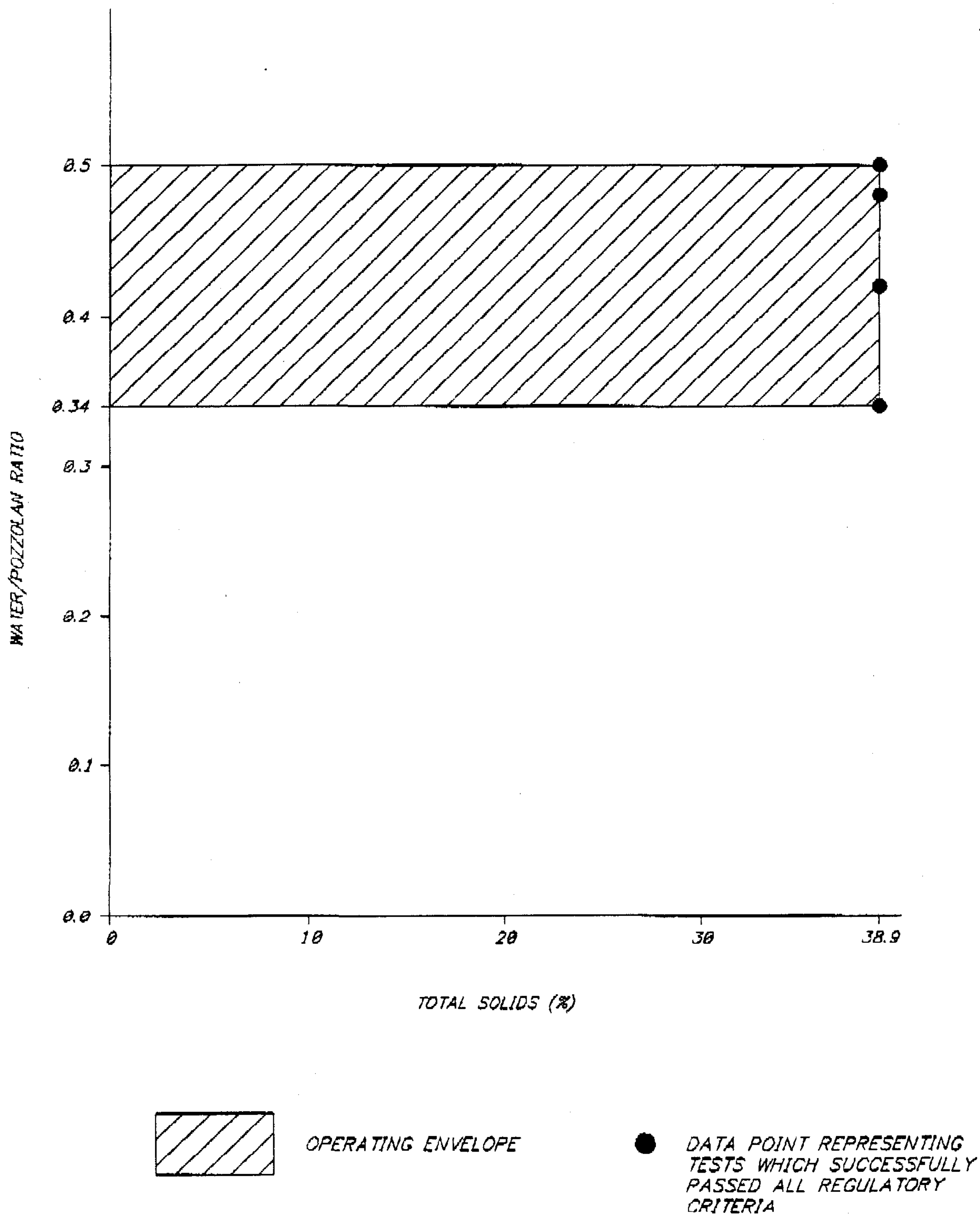

FIGURE 3-14

WATER TO POZZOLAN RATIO vs TOTAL SOLIDS
POND 207C AND CLARIFIER
LIME/CEMENT/FLYASH/LATEX
ROCKY FLATS, GOLDEN, COLORADO

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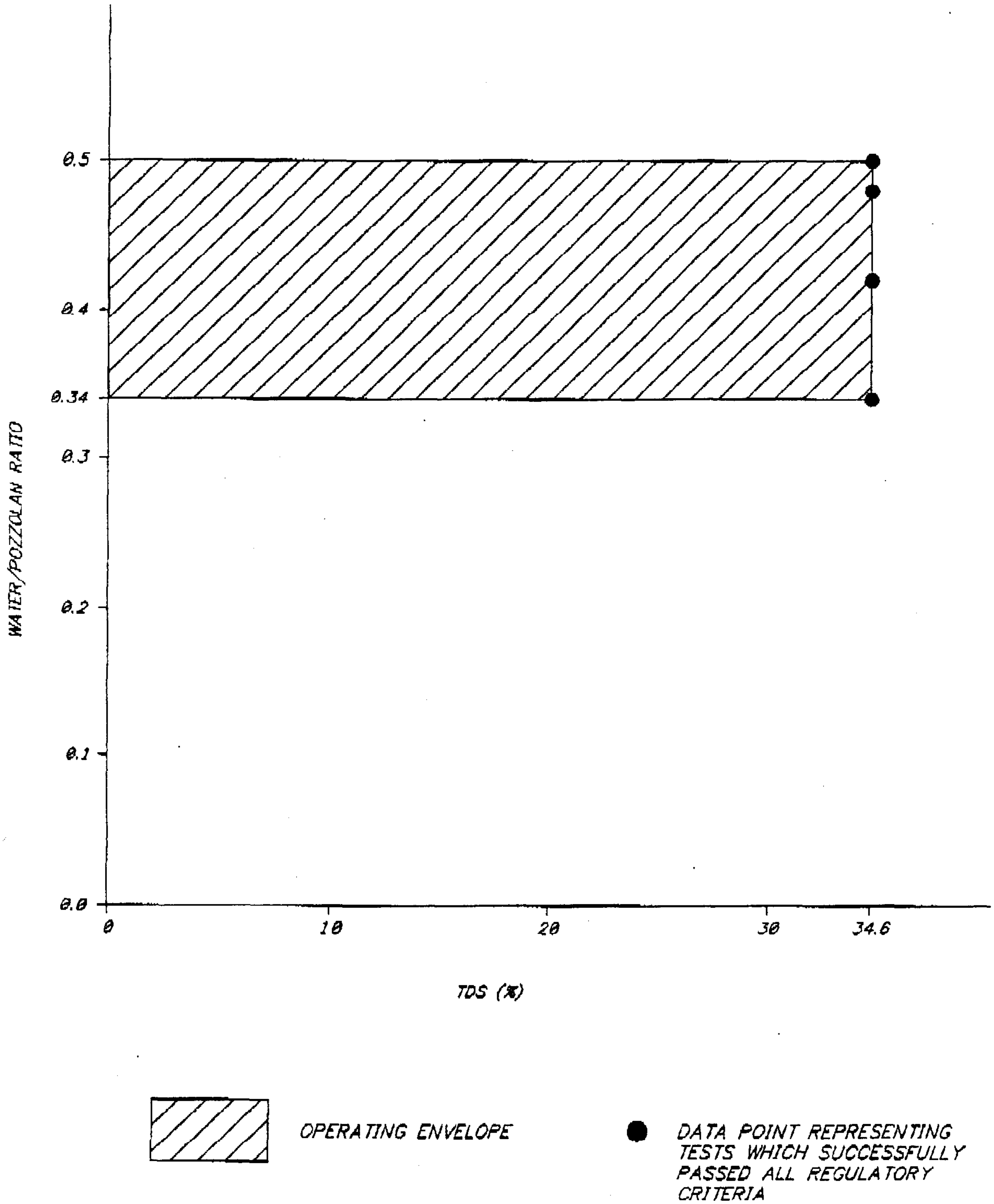

FIGURE 3-15

WATER TO POZZOLAN RATIO vs TOTAL DISSOLVED SOLIDS
POND 207C AND CLARIFIER
LIME/CEMENT/FLYASH/LATEX
ROCKY FLATS, GOLDEN, COLORADO

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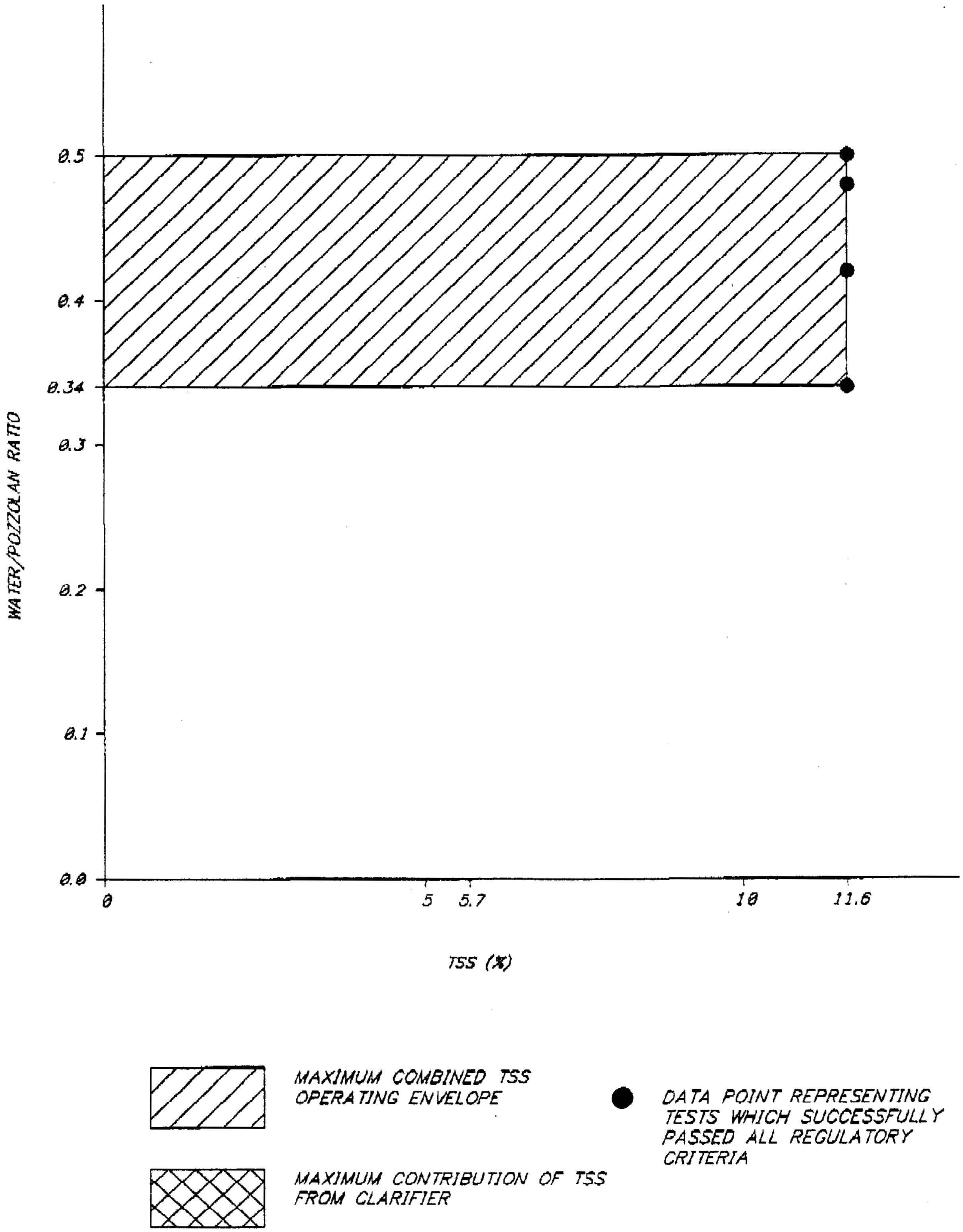

FIGURE 3-16

WATER TO POZZOLAN RATIO vs TOTAL SUSPENDED SOLIDS
POND 207C AND CLARIFIER
LIME/CEMENT/FLYASH/LATEX
ROCKY FLATS, GOLDEN, COLORADO

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4.0 PHYSICAL PROPERTIES OF FORMULATIONS

During processing, the contents of the Pond 207C and the Clarifier will be mixed with the pozzolans in a Halliburton Services Recirculating Mixer (RCM). The RCM essentially consists of an agitated tank into which the waste and the pozzolans are added and vigorously mixed using a centrifugal pump in a recirculating line. Enough pozzolans are added to the tank to achieve the desired mix-density. The RCM also has an adjacent agitation tank into which the mixture overflows before exiting the system as the output product.

The physical characteristics of the mixed formulation during the process of mixing and subsequent process operations effect the material handling and mixer design. This information is also essential to estimating mixing time and the allowable time for operations at the casting station. The physical properties of the cemented slurry fall in three significant categories for the purposes of this discussion:

- Rheological Properties
- Dynamic and Static Parameters and
- Air Entrainment.

It has to be noted that all the tests described in this section used pozzolans composed of 1 part Type V Cement, 2 parts Class C Flyash, and 0.075 parts hydrated lime. The 207C sample used had a TDS of 33.1% and TSS of 7.4%. The 207C/Clarifier sample used had a TDS of 34.6% and TSS of 11.6%.

4.1 RHEOLOGICAL PROPERTIES

The rheological properties of the waste/pozzolan mixtures were examined to ascertain the flow characteristics of the material in the RCM under applied stress. The measurements were conducted using a Fann VG Meter which is a direct-reading viscometer in which the mixture is sheared between two coaxial cylinders - the bob and the sleeve. The dimensions of the rotor sleeve and the bob are specified in API RP 13B. The shear stress (scale reading) is determined as a function of the shear rate (from the speed of rotation). The instrument used for our studies was the model with six rotation speeds. The instrument is calibrated so that the dial reading at any fixed rpm setting gives the shear stress in $lbs/100ft^2$ at that shear rate.

The data obtained from the Fann VG Meter studies are shown in Figure 4.1. The studies on Pond 207C were conducted at different water to pozzolan ratios. As can be seen from the graph, the shear stress increases as the water content of the mixture goes down.

The almost linear plots in the figure indicate that the Bingham Plastic Model gives a reasonable description of the fluid. As the water to pozzolan ratio increases, the curves become more linear. It has to be noted though that the readings at very low pozzolan concentrations should be ignored since they were unduly influenced by the thixotropic nature of the slurry.

The Bingham Plastic model is the rheological model that is most used when dealing with cement slurries. It is the simplest model for non-Newtonian fluids. The data from the Fann VG meter was used to obtain the two parameters in the Bingham Plastic Model - Plastic Viscosity (PV) and Yield Point (YP).

Plastic Viscosity is that part of the resistance to flow caused by mechanical friction. It is principally affected by

- the solids concentrations
- the size and shape of the solids and
- the viscosity of the fluid phase.

Yield Point is that part of the resistance to flow caused by the attractive force between the particles. This attractive force is caused by the charges on the surface of the particles dispersed in the fluid phase. This force is dependent on

- the type of solids and surface charge associated with them
- the amount of solids and
- the concentration of salts contained in the fluid phase.

The Plastic Viscosities and the Yield Points of the various mixtures studied are shown in Table 4-1.

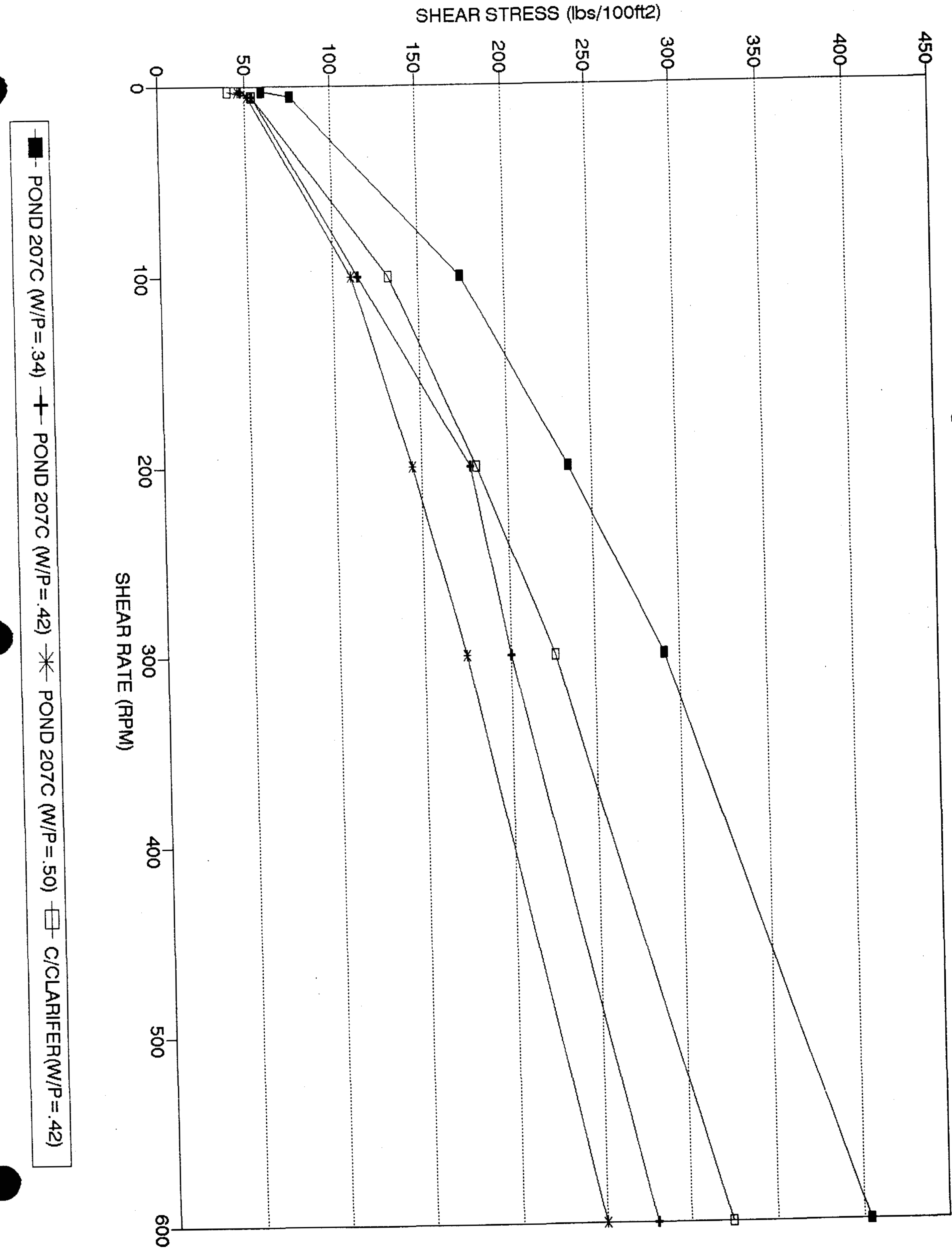


Figure 4.1 FANN DATA ON RHEOLOGIES

TABLE 4-1

RHEOLOGICAL PROPERTIES OF 207C/CLARIFIER MIXES

Formulation	Plastic Viscosity	Yield Point
Pond 207C Water/Pozzolan =0.34	114	176
Pond 207C Water/Pozzolan =0.42	80	120
Pond 207C Water/Pozzolan =0.50	76	98
Pond 207C/Clarifier Water/Pozzolan =0.42	98	128

The main significance of the information in Table 4-1 was to enable the production of surrogates which could be used to conduct field tests with the equipment to be used for processing. Field tests conducted in Duncan, OK have successfully demonstrated the use of the RCM for the mixing requirements of the formulation on surrogate wastes.

4.2 DYNAMIC AND STATIC PARAMETERS

Studies were also conducted to characterize the setting behavior of the formulations and the time taken to achieve setting. The gelling characteristics were studied under both dynamic and static conditions. Dynamic conditions are designed to represent normal process operating conditions and static conditions similar to what would be encountered during emergency shut-downs.

Pumping times

The time period after mixing within which the waste mixed with the pozzolans can be pumped is a critical design parameter. It is generally accepted that a slurry becomes unpumpable when the consistency reaches 70 units. The period of time from the start of a test until 70 units of consistency is reached is referred to as the pumping time. It is an estimate of the workable fluid life of the slurry. Obviously, the actual job time should be less than the pumping time and safety factors of 30% to 50% are common.

The pumping times of the formulations were measured using a Halliburton Atmospheric Consistometer. The instrument essentially consists of a container in which the slurry is continuously mixed with a paddle. As the slurry viscosity increases, the drag encountered by the paddle is measured by a calibrated spring and is registered as units of slurry consistency.

The consistency-time curves under Dynamic conditions for the 207C and the 207C/Clarifier slurries are shown in Figures 4.2 and 4.3. The slurry initially has a fairly low consistency. With time, this value usually drops a little more. It then proceeds to increase gradually. At some point the rate of increase of consistency becomes highly accelerated such that the curve is very steep. The low water slurries tested (water to pozzolan ratio of 0.34) had their sharp breaks in the curve after two hours. At the water to pozzolan ratio of 0.50, the 207C slurry reached its breakpoint after 4.5 hours and the 207C/Clarifier slurry after 10 hours. As is reasonable to expect, the allowable pumping times decrease as the water content in the slurry is reduced.

Static Gel Strengths

According to API RP 13B, two values are indicative of the static gel strength, the 10 second gel strength (Initial Gel Strength) and the 10-minute gel strength, and are determined using the Fann VG meter.

The static gel strengths give an indication of the rate of gel strength development after the slurry has been mixed and allowed to remain static. The static gel strengths of several of the formulations are listed in Table 4-2.

TABLE 4-2

STATIC GEL STRENGTHS OF 207C/CLARIFIER MIXES

Waste Matrix Formulation	Initial Gel Strength ($lbs/100ft^2$)	10-Minute Gel Strength ($lbs/100ft^2$)
Pond 207C Water/Pozzolan =0.34	70	410
Pond 207C Water/Pozzolan =0.42	54	360
Pond 207C Water/Pozzolan =0.50	44	350
Pond 207C/Clarifier Water/Pozzolan =0.42	40	144

Figure 4.2 CONSISTENCY UNDER DYNAMIC CONDITIONS - 207C

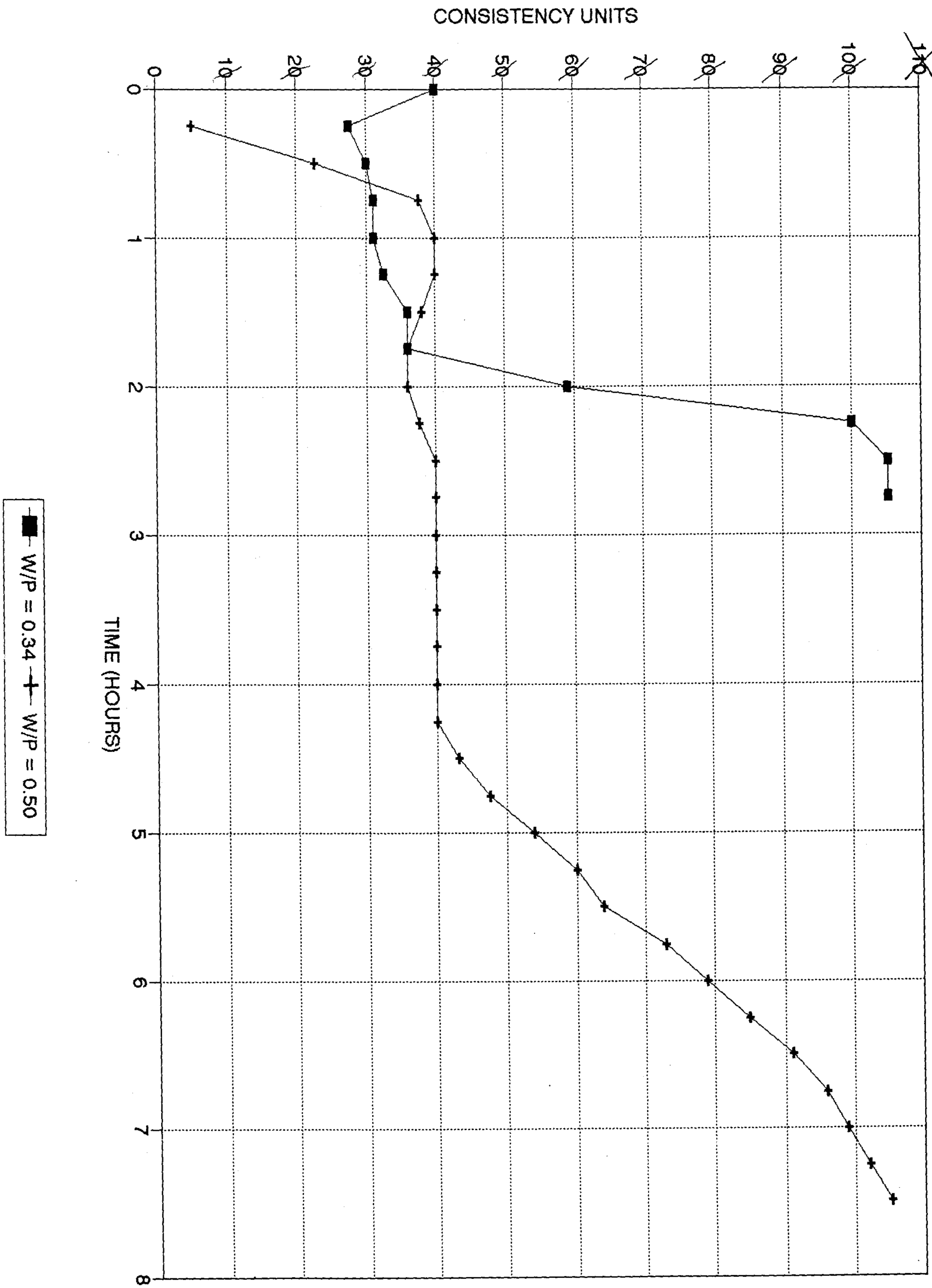
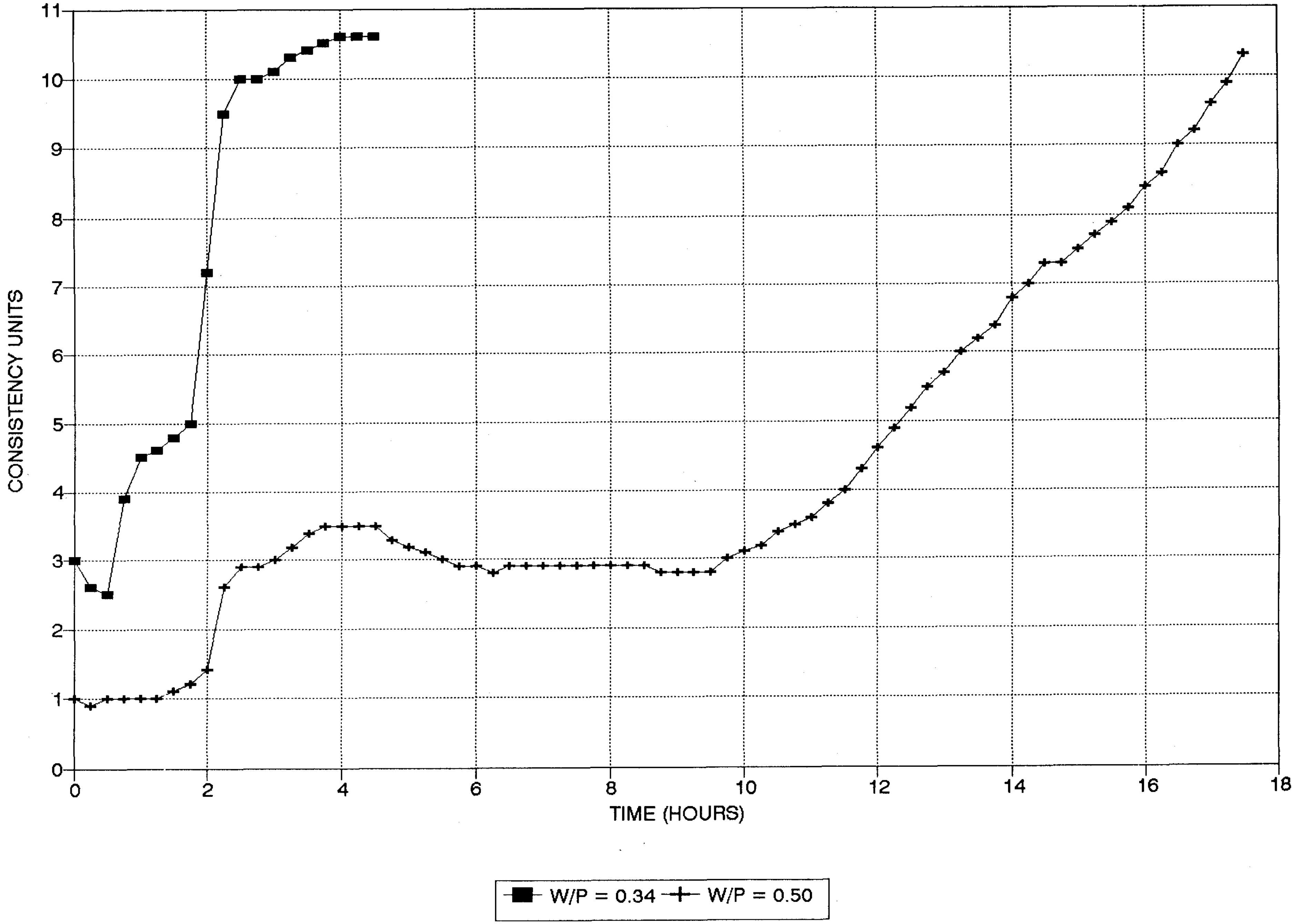


Figure 4.3 CONSISTENCY UNDER DYNAMIC CONDITIONS - 207C/CLARIFIER



The large difference between the initial gel strengths and the 10-minute gel strengths indicates that the slurries develop gel strength rapidly during static periods. This information is important in determining the horsepower required to move the slurry in case of an unplanned job shutdown. The Pond 207C slurries set up slower as the water content increases, although the slow-down is only marginal. In comparison, the static set up time for the 207C/Clarifier mixture is much longer than that for just 207C.

4.3 ENTRAPPED AIR

The entrapment of air during the mixing of the waste slurry with the pozzolans in the RCM was simulated in the laboratory as part of the treatability studies. The RCM mixing was simulated in the laboratory with a Waring blender using a testing methodology developed by Halliburton Services Completions Research and Engineering Department.

The air entrapped in the various formulations was measured using a mud scale with a pressurizing plunger to squeeze the entrapped air from the slurry samples. Table 4-3 lists the percent air (by volume) entrapped in each of the formulations when subjected to mixing similar to that in an RCM.

TABLE 4-3

ENTRAPPED AIR IN CEMENTED PRODUCT

Waste Matrix	Water/Pozzolan Ratio	% Air in Slurry
207C	0.34	2.64
207C	0.50	4.57
207C	0.34	3.33
207C/Clarifier	0.50	4.39

The percent air entrapped in all these samples are well within what would be normally observed in regular concrete work. Typically, acceptable ranges vary from 6 to 10% air for concrete that contains aggregate 10 mesh or less in size (Portland Cement Association, 1979). In any event, if the need for deaerating chemicals may arise during the actual field operations, the addition of those chemicals in the formulations have been successfully demonstrated as detailed in Section 3.0.

During field operations, the entrapped air in the system will be measured several times a day to accommodate for its influence on the density of the product. It is expected that the presence of a certain amount of entrapped air in the product may have a beneficial influence by providing a limited amount of freeze/thaw protection. This protection is less than what would be expected for entrained air. Air entrained concrete, which is produced through the use of an air entraining admixture, consists of fine bubbles that are uniformly displaced throughout the concrete. Entrapped air is typically larger in size than entrained air and can be detrimental to concrete if present in very large quantities.

4.4 SPECIFIC CONDUCTANCE VS. TDS FOR POND 207C WATER

In order to obtain a rapid estimation of the Total Dissolved Solids (TDS) in the 207C pond mixture, specific conductance measurements will be made. Tests were performed in the laboratory to determine the relationship between the specific conductance and percent TDS of Pond 207C water. A saturated 207C water sample with no suspended solids was prepared and analyzed. This sample was then diluted from its saturated state of 40.3% TDS to 30.2%, 20.1%, 15.1%, 10.1%, and 5.0% TDS, and the corresponding specific conductance determined. These data are summarized on Table 4-4.

Figure 4-4 graphically presents the relationship between percent TDS and specific conductance. At the higher TDS levels (>30%), accurate readings for specific conductance on 207C water are difficult to obtain (See Table 4-4). The graph shows an estimated protection for the specific conductance values above 30% TDS.

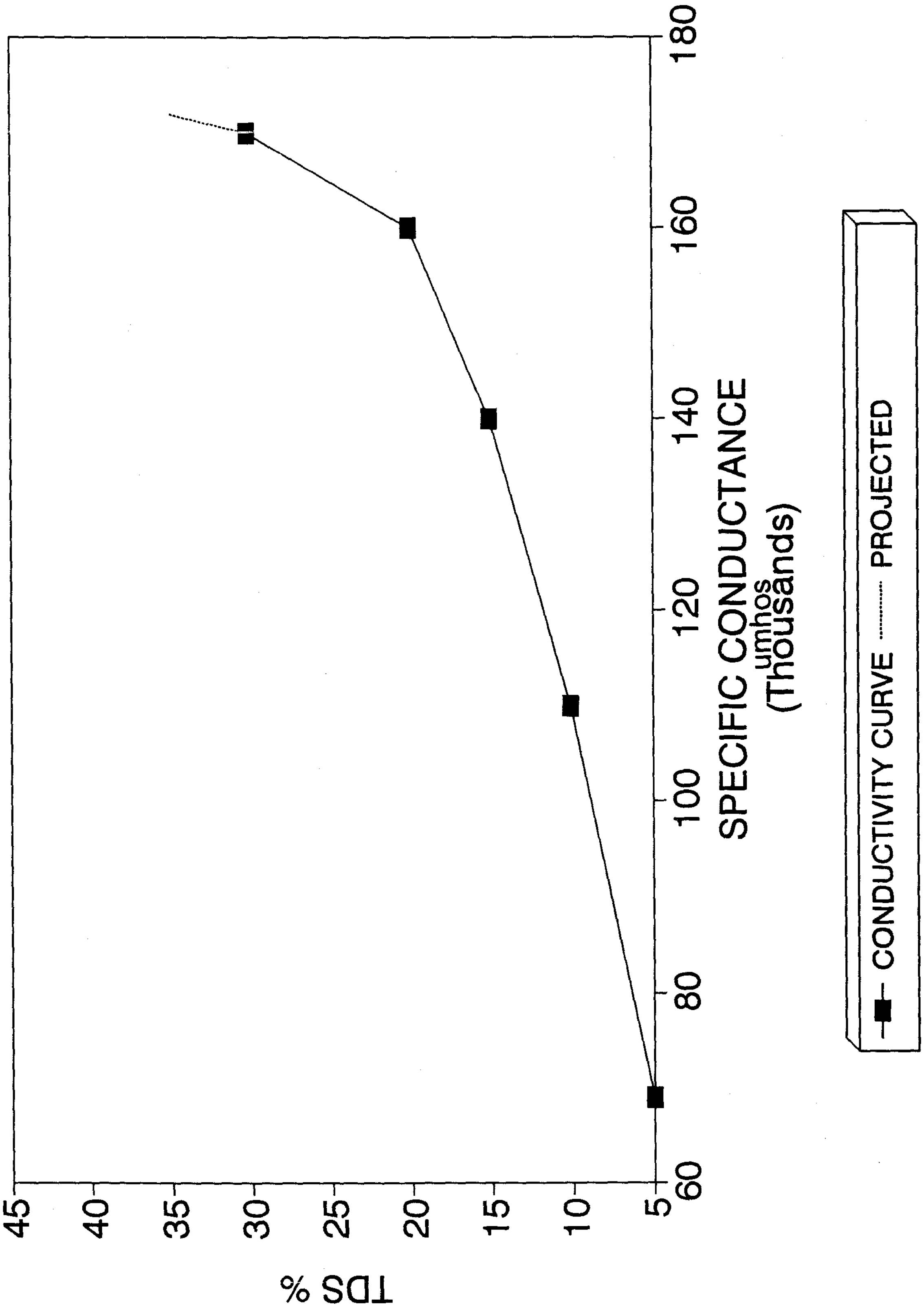
TABLE 4-4

SPECIFIC CONDUCTANCE VS. TDS
POND 207C WATER

Sample	Specific Gravity	TDS	Specific Conductance(2) (umhos/cm)
1	1.035(1)	5.0%(1)	69,000
2	1.073(1)	10.1%(1)	110,000
3	1.113(1)	15.1%(1)	140,000
4	1.157(1)	20.1%(1)	160,000
5	1.257(1)	30.2%(1)	170,000
6	1.365(2)	40.3(2)	160,000
7 (Duplicate)	1.365(2)	40.3%(2)	170,000

(1) Calculated values based on dilution of concentrated sample.
(2) Laboratory Analytical Data.

FIGURE 4-4
TDS VS. SPECIFIC CONDUCTANCE



5.0 PROCESS CONTROL PHILOSOPHY

The results of the treatability testing for the treatment of 207C and 207C/ Clarifier waste as explained in the previous sections have to be utilized to develop an operational process defined by an envelope, and effectively controlled within it, to produce a certifiable product. This section summarizes the operational envelope from a process control standpoint and details the control philosophy on which basis the process will be operated.

5.1 OPERATIONAL ENVELOPE

To produce a certifiable product, the stabilization operation has to be conducted within a process operating envelope which has been proven in the laboratory. HALLIBURTON NUS has developed recipes that have passed all Land Disposal Restriction, free liquids, and Department of Transportation requirements. In addition to meeting the regulatory requirements, the cited recipes have also performed satisfactorily in durability tests using ASTM wet/dry and freeze/thaw procedures.

The recipes are based on a specified amount of pozzolans to be added to the waste stream such that the ratio of free water to pozzolans falls within a defined regime. Free water has been defined as the total mass of water in the slurry less the total solids. The pozzolans are to be pre-blended in a fixed ratio of cement to flyash to lime. Pozzolans are defined in the context of this process as mixtures of cement, flyash, and lime which when combined with water in the correct ratio forms a solidified waste product. The other parameters that are necessary to provide a complete definition of the operating envelope are TSS (Total Suspended Solids) and TDS (Total Dissolved Solids) of the waste stream. The Total Solids (TS) referred to in this document includes both TSS and TDS.

5.1.1 <u>Sample Calculation of Pozzolan Requirement</u>

For a slurry with Total Solids (TS) = 32%,

Free Water in Slurry = 100-TS = 100-32 = 68%

To achieve a water to pozzolan ratio of 0.42,

For 100 gms of slurry, the amount of pozzolans that have to be added would be:

Pozzolans = Free Water ÷ 0.42 = 68 gms ÷ 0.42 = 161.9 gms

The pozzolans would be pre-blended in the cement:flyash:lime ratios indicated in the recipes.

5.1.2 Operational Envelope for Pond 207C Slurry

The envelope for recipe formulation for stabilization of the contents of Pond 207C is shown in Figures 3-1 to 3-3. In order to consolidate the information in the form of a table (Table 5-1), some of the data has been intentionally left out. It has to be remembered that the true envelope is broader than what is indicated by Table 5-1.

Table 5-1 Operational Envelope for Pond 207C

Water /Pozzolan Ratio	**0.34 to 0.50**
Upper Limit for TSS in Input Slurry	17.2%
Upper Limit for TDS in Input Slurry	40.4%
Pozzolan Composition: Cement:Flyash:Lime	1:2:0.075

TS limit = 47.1% cert fig 3-2

The operational upper limits for TSS and TDS indicated in Table 5-1 are those limits on the input slurry below which the output product would be certifiable. The operational range for the water to pozzolan ratio is the regime within which the output product is certifiable. However, the process will be operated at the mid-point of the range defined by the envelope (i.e. at a water to pozzolan ratio of 0.42).

5.1.3 Operational Envelope for 207C/Clarifier Slurry

The envelope for recipe formulation for stabilization of the mixture of Pond 207C and Clarifier contents is shown in Figures 3-5 to 3-8. The operational envelope is also tabulated in Table 5-2. Here again, due to the limitations of the format in which it is presented, the table reduces the scope of the operating envelope. It has to be remembered that the true envelope is broader than what is indicated by Table 5-2. The difference between this and the 207C recipe shown in Table 5-1 is that for the 207C/Clarifier slurry, in addition to the upper limits for TDS and TSS, the envelope has an upper limit of Clarifier TSS.

Table 5-2 Operational Envelope for Pond 207C/Clarifier

Water /Pozzolan Ratio	0.34 to 0.50
Upper Limit for Total TSS in Input Slurry	11.6%
Upper Limit for Clarifier TSS in Input Slurry	5.7%
Upper Limit for TDS in Input Slurry	34.6%
Pozzolan Composition: Cement:Flyash:Lime	1:2:0.075

∴ TS ≤ 11.6+34.6 = 46.2% TS

As in the case of the 207C Process, it has been decided to operate the 207C/Clarifier process at the mid-point of the water to pozzolan ratio range that is permitted by the envelope (i.e. a water to pozzolan ratio of 0.42).

5.2 CONTROL CONCEPTS

To maintain adherence to the operating envelope proven in the laboratory and outlined in Section 5.1, a scheme has been developed to maintain effective process control for 207C and 207C/Clarifier processing. This section summarizes the objectives and the philosophy of control.

5.2.1 Control Objectives

The principal process control objective is to accurately mix the contents of Pond 207C and 207C/Clarifier with pozzolans such that a water to pozzolan ratio of 0.42 can be maintained. It is also required that the TDS and TSS of the input slurry be maintained below the upper limits defined by the operating envelope.

5.2.2 Control Options

5.2.2.1 Method of Control

Two options exist as to the method of control that can be exercised to achieve the stated objective.

Option 1 Feed-forward Control

A feed-forward control scheme would involve addition of a measured amount of pozzolans to the mixing tank to produce a mix at the desired water to pozzolan ratio. This could be accomplished by volumetric or gravimetric solids feed systems.

Option 2   Feedback Control

A feedback control scheme would involve control of the pozzolan addition by measuring the amount of it present in the output slurry. This is a far more effective and precise method to control the process.

5.2.2.2 Method of Measurement

The two critical measurements that need to be made for effective feedback control are the defining parameters for the input and output slurry.

Several options exist for parametric measurements to define the input slurry.

Option 1   Water Content Measurement

The ideal parameter to control would be the water content of the input slurry. However, no reliable technology exists to conduct this measurement.

Option 2   Total Solids Measurement

Obtaining the Total Solids measurement from individual Total Dissolved Solids and Total Suspended Solids measurement devices would indirectly provide the water content of the slurry. However, the incremental error involved in computing a value obtained from two separate devices discourages this option.

Option 3   Specific Gravity Measurement

The Halliburton Nuclear Densimeter provides reliable specific gravity measurements that are accurate to within 1%. The specific gravity of the slurry is an indirect measure of the water content of the slurry. However, as shown in Section 5.3.2, although water content and slurry specific gravity are almost directly proportional to each other, they are not exactly so.

There are not as many options to measure a defining parameter of the output slurry. Measuring the specific gravity of the output slurry using the densimeter seems to be the only consistently reliable and proven option available.

In the light of the above discussion, it is reasonable to choose a feedback scheme for process control of the Pond 207C and 207C/Clarifier process, with specific gravity being the defining parameter of the input and output slurries.

5.2.3 Control Philosophy

The 207C and the 207C/Clarifier waste forms contain suspended and dissolved solids. Water makes up the remainder of the waste. To produce a waste form that is certifiable, pozzolans have to be added to the waste to achieve a water to pozzolan ratio of 0.42. The water to pozzolan ratio will be maintained in this process by measuring the input slurry specific gravity and controlling the output slurry specific gravity.

The waste form will be consolidated and homogenized in batch tanks after lowering the TDS and TSS to within acceptable limits. The homogenized slurry will have a specific gravity which can be measured using a densimeter. The specific gravity will be dependent on the amount of TDS and TSS in the slurry. The input slurry specific gravity can also be related to the water content in the slurry.

When the waste slurry is mixed with pozzolans in a water to pozzolan ratio of 0.42, the specific gravity of the resulting mix is dependent on the pozzolan specific gravity. Thus the input slurry specific gravity (by virtue of its relationship with water content) can be related to the output product specific gravity. It is demonstrated in subsequent sections that the calculated output specific gravity value matches the values obtained in the laboratory. Thus an output product specific gravity can be calculated for the input slurry specific gravity for a given water to pozzolan ratio.

The RCM mixes the waste slurry with the pozzolans using an automatic control system which controls the pozzolan addition by means of a throttle valve to achieve any desired output product specific gravity. The Automatic Density Controller of the RCM utilizes the slurry feed rate and the calculated output specific gravity set-point to regulate pozzolan addition. This effectively provides the feedback control scheme utilizing input and output slurry densities.

5.3 MECHANISM OF PROCESS CONTROL

This section provides details on the various steps involved in the control of the 207C Process. It also provides the backing for the concepts outlined in Section 5.2.

For control purposes, the process can be segmented into:

- Preparation of the waste slurry such that it is within the permissible limits for TSS and TDS as set by the operational envelope in Section 3.0

- Measurement of the specific gravity of the input waste slurry to the RCM

- Computation of the set-point for the RCM output slurry specific gravity

- Control of the output slurry specific gravity using the Automatic Density Controller (ADC) of the RCM.

5.3.1 Preparation of Waste Slurry

The waste will initially have to be converted into a treatable form as defined by the operational envelope. The contents of Pond 207C will be transferred into averaging tanks, located near the pond, where the TSS will be maintained below the upper limit by the addition of water from the pond itself, and TDS will be maintained below the upper limit by the addition of water from a fresh water source.

This slurry from the averaging tanks will be transferred to two sets of batch tank pairs. The slurry will be recirculated in a set of batch tanks before it is fed to the RCM. Before the slurry leaves the batch tanks, a final confirmation will be made that the TDS and TSS values are below the upper limits. Fresh water, for dilution, will be added to the batch tanks if it is deemed necessary.

The Clarifier contents can be added to the 207C slurry such that the TSS contribution from the Clarifier does not exceed the upper limits defined in the process envelope described in Section 5.1.3.

5.3.2 Specific gravity of Input Waste Slurry

The specific gravity of the waste slurry prepared in the batch tanks will be measured in the batch tank instrument loop. This value is critical for process control and will be measured for each batch.

Each batch will be recirculated between the tanks to achieve homogenization. When the slurry is completely homogenized, the slurry specific gravity measurement will reach a steady value. The specific gravity of the slurry mixture entering the RCM will be dependent on the amount of dissolved salts (TDS) and silt (TSS).

The average specific gravities of the salt and silt in Pond 207C and that of the silt in the Clarifier are detailed in Table 5-3. These values were obtained from laboratory experiments. Details on how these values were obtained are provided in Attachment G.

Table 5-3 SPECIFIC GRAVITIES OF SALT/SILT

Apparent Specific Gravity of dissolved Pond 207C Salt	3.10
Specific Gravity of Pond 207C Silt	2.23
Specific Gravity of Clarifier Silt	2.73

Figure 5-1 shows the slurry specific gravity at various combinations of TDS and TSS for Pond 207C in the operating region of the process. As can be expected, the densities of the slurries increase with increasing amounts of TDS and TSS. A similar relationship exists for the 207C/Clarifier slurry. In the case of the 207C/Clarifier slurry, the slurry specific gravity will be dependent on the amount of Clarifier TSS which is part of the total TSS.

Figures 5-2 and 5-3 show that regardless of the individual contributions of TSS and TDS, the specific gravity of the slurry is proportional to the water content of the slurry. Although not perfect, for all practical purposes, the relationship is linear.

5.3.3 Specific Gravity of Output Cemented Slurry

The specific gravity of the waste slurry entering the RCM will be used to set the specific gravity of the output cemented product at a given water to pozzolan ratio. The ADC of the RCM will add enough pozzolans to the RCM such that the specific gravity of the output product will be maintained at any desired set-point.

The specific gravity of the output slurry can be calculated precisely, based on the specific gravity of its components (TDS, TSS and the Pozzolans) and their respective compositions. This value will be the set-point to which the Automatic Density Controller of the RCM will effect control.

Figure 5-1 INPUT SLURRY SPECIFIC GRAVITY FOR POND 207C

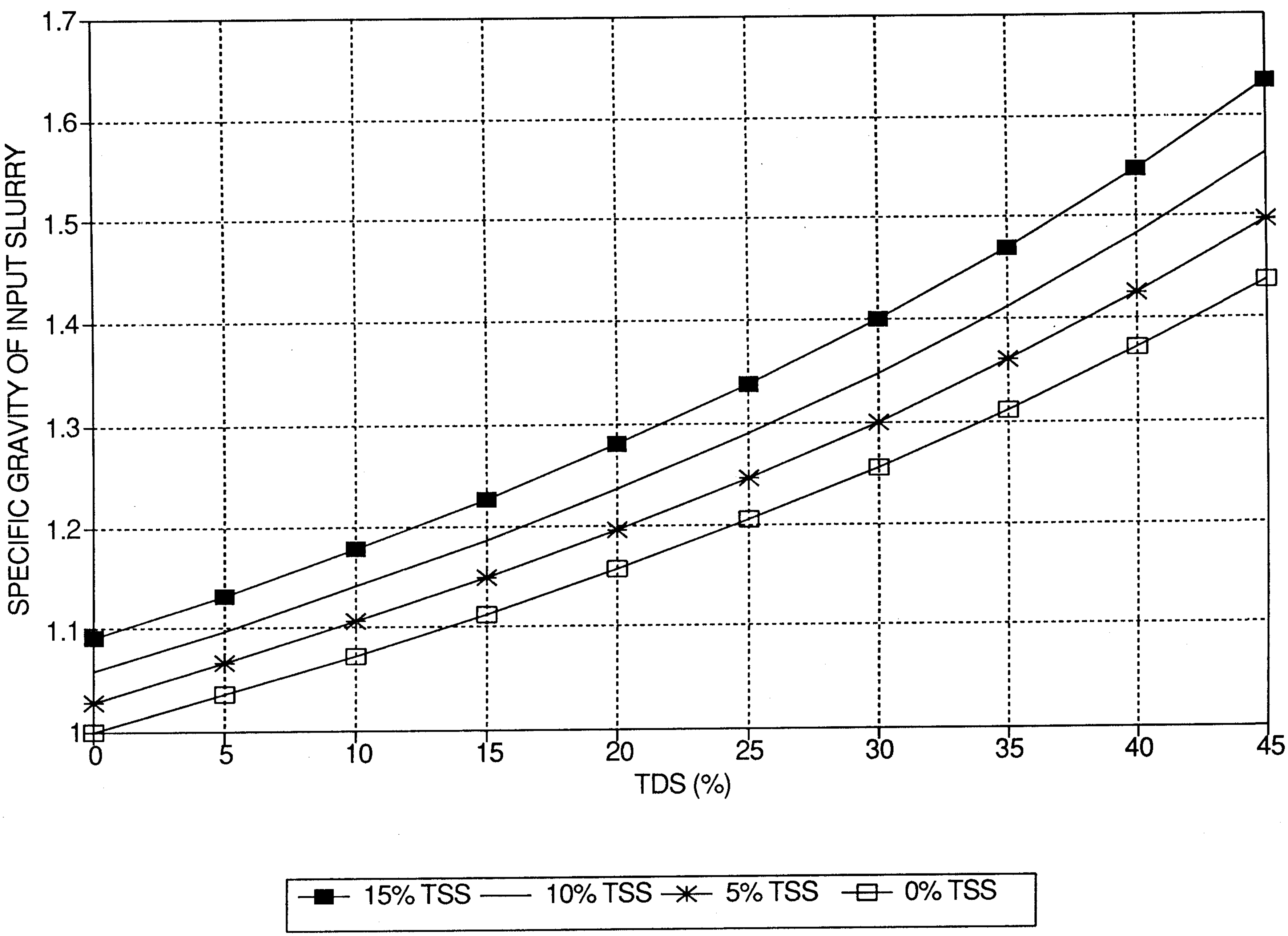


Figure 5-2 INPUT SLURRY SP. GRAVITY AS A FUNCTION OF WATER CONTENT AND % TSS

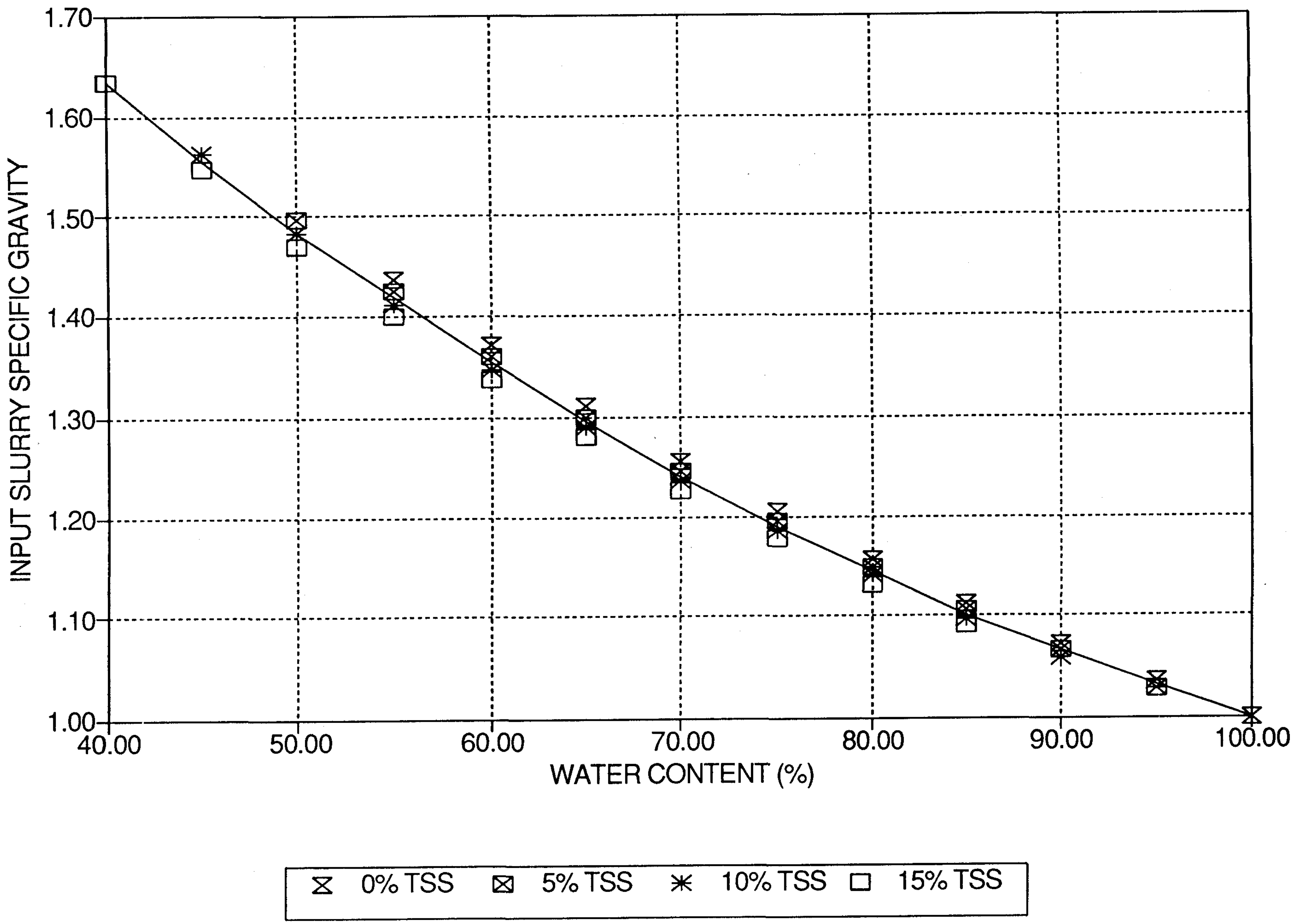
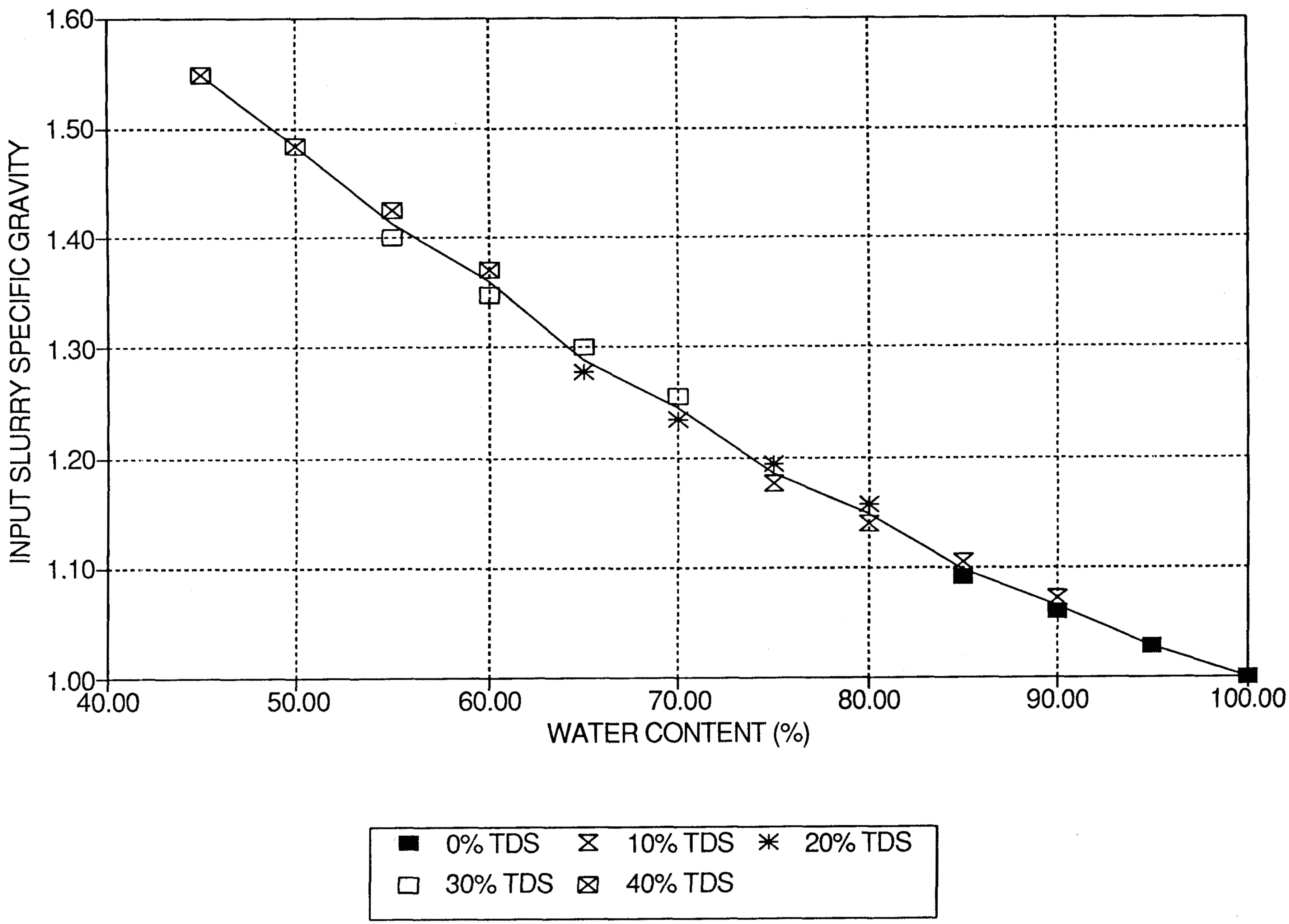


Figure 5-3 INPUT SLURRY SP. GRAVITY AS
A FUNCTION OF WATER CONTENT AND %TDS



The output slurry specific gravity will therefore depend on:

- the specific gravity of the incoming slurry
- the specific gravity of the pozzolan mixture and
- the water to pozzolan ratio at which the process is being conducted.

The specific gravities of the output product for 207C processing for a range of dissolved and suspended solids loadings has been calculated and is shown in Figure 5-4. The specific gravity of pozzolans used in these calculations is 2.9. Figure 5-4 represents linear fits of a range of computed values over three different water to pozzolan ratios.

Figure 5-5 shows the same relationship for the 207C/Clarifier slurry. Since the 207C/Clarifier mixture can have varying amounts of TSS contributions from each, the figure represents a case where the TSS contributions from 207C and Clarifier are 1:1.

5.3.4 Computation of Output Product Specific Gravity Set-point

As mentioned in the previous section, the lines in Figure 5-4 represent the output specific gravities for 207C waste over a range of input slurry densities using pozzolans with a specific gravity of 2.9. Similar graphs can be generated for different pozzolan specific gravities.

To cover all possible variations of pozzolan specific gravity, input slurry specific gravity and water to pozzolan ratios, the following equation (Equation 1) was developed for the output slurry specific gravity.

EQUATION 1

$$\text{Output Specific Gravity} = ABC(0.11812) - BC(0.10007) + AC(0.336412) + C(0.357566) - AB(0.670010) + B(0.614441) + A(0.1301930) + 0.477074$$

where

where	**A**	**=**	**Water to Pozzolan ratio**
	B	**=**	**Specific Gravity of Pozzolans**
	C	**=**	**Specific Gravity of Input Slurry**

Lab data confirmed the above equation. The comparison between the measured and calculated values is tabulated in Table 5-4.

Figure 5-4 OUTPUT SLURRY SPECIFIC GRAVITY FOR POND 207C

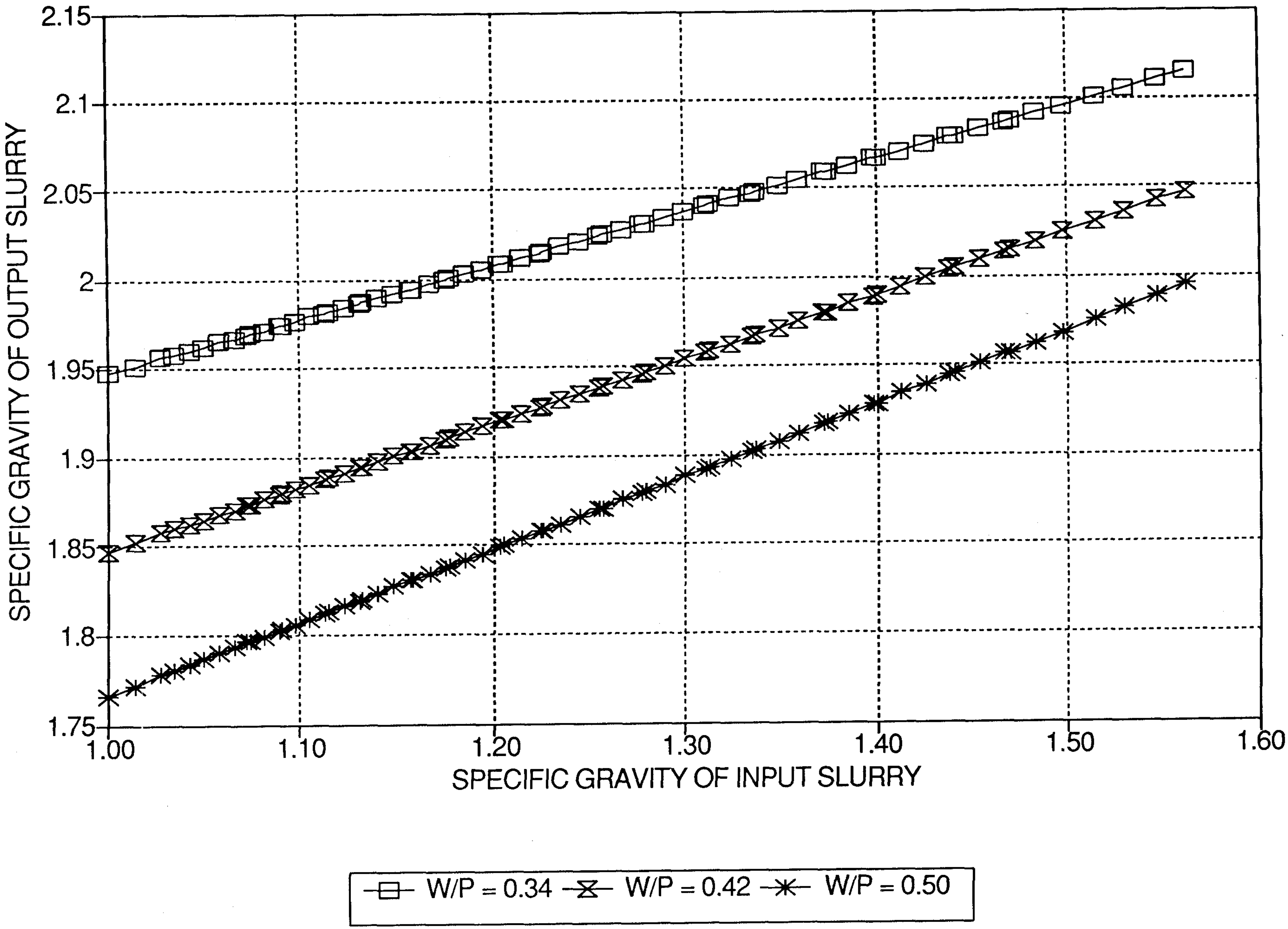


Figure 5-5 OUTPUT SLURRY SP. GRAVITY
FOR 207C/CLARIFIER (1:1 TSS)

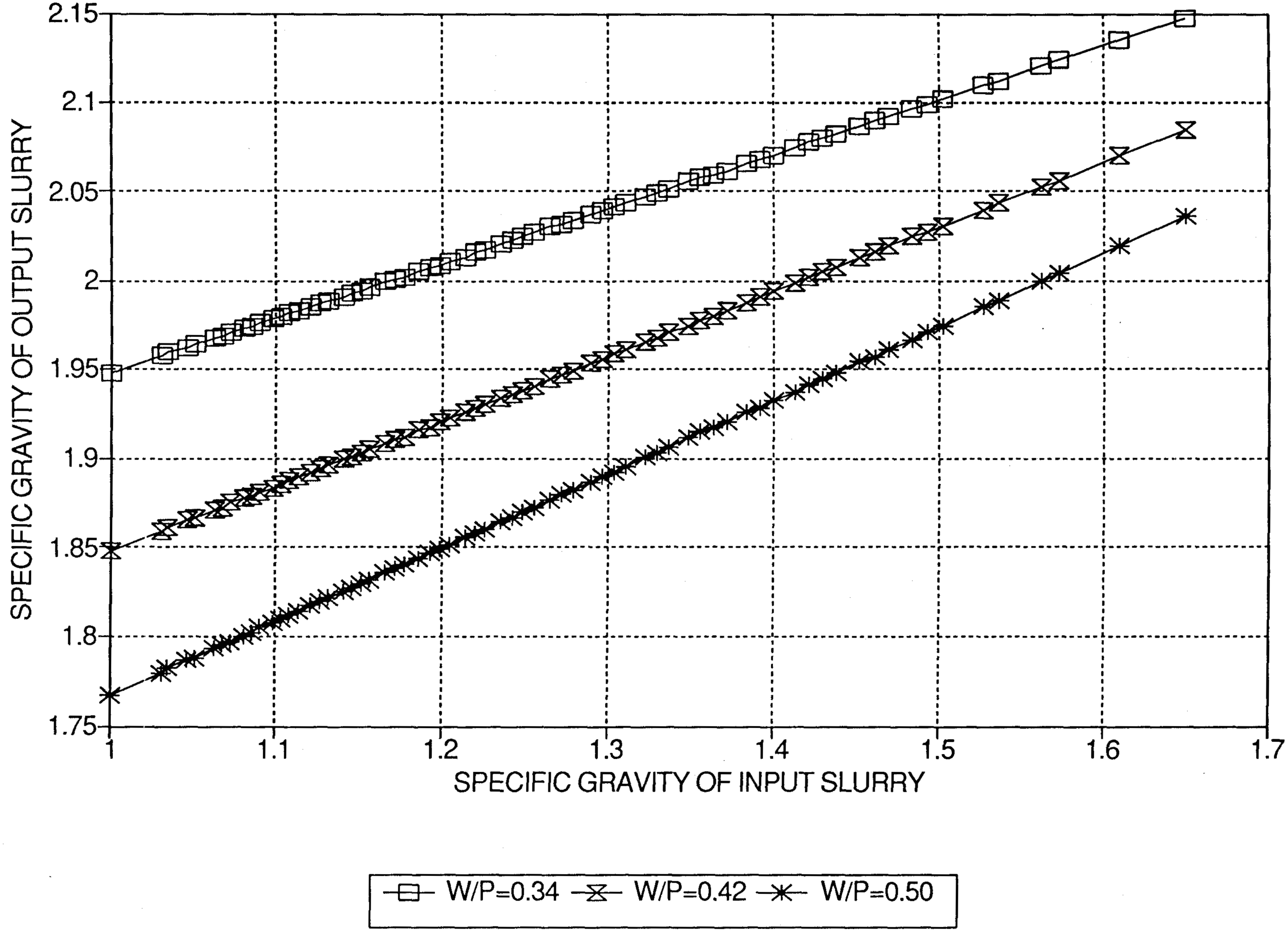


TABLE 5-4 COMPARISON OF EQUATION 1 WITH LAB DATA

W/P Ratio	Pozzolan Sp. Gr.	Input Slurry Sp. Gr.	Calculated Output Sp.Gr.	Measured Output Sp. Gr.	% Difference
0.42	2.9	1.000	1.850	1.869	1.0
0.34	2.9	1.222	2.007	2.001	-0.3
0.42	2.9	1.222	1.928	1.917	-0.6
0.50	2.9	1.222	1.850	1.821	-1.5
0.34	2.9	1.302	2.031	2.013	-0.9
0.42	2.9	1.302	1.957	1.965	0.4
0.50	2.9	1.302	1.882	1.917	1.8
0.34	2.9	1.336	2.041	2.037	-0.2
0.42	2.9	1.336	1.969	1.941	-1.4
0.50	2.9	1.336	1.896	1.905	0.5

Since the process will be conducted at a water to pozzolan ratio of 0.42, output specific gravity can be expressed using the following simpler equation (Equation 2).

EQUATION 2

Output Specific Gravity = − BC(0.04956) + C(0.499774) + B(0.3283) + 0.536386

$$\text{Output Specific Gravity} = -BC(0.04956) + C(0.499774) + B(0.3283) + 0.536386$$

where B = Specific Gravity of Pozzolans
C = Specific Gravity of Input Slurry

The values computed using Equation 2 match well with the values measured in the laboratory, as shown in Table 5-5.

TABLE 5-5 COMPARISON OF EQUATION 2 WITH LAB DATA

W/P Ratio	Pozzolan Sp. Gr.	Input Slurry Sp. Gr.	Calculated Output Sp. Gr.	Measured Output Sp. Gr.	% Difference
0.42	2.9	1.000	1.845	1.869	1.3
0.42	2.9	1.222	1.924	1.917	-0.3
0.42	2.9	1.302	1.952	1.965	0.7
0.42	2.9	1.336	1.964	1.941	-1.2

Since the pozzolan specific gravity cannot be expected to remain exactly the same over the duration of the process, further simplification of the equation may not be possible.

An equation was also developed for the 207C/Clarifier mix. It covers all possible variations of pozzolan specific gravity, input slurry densities, and the percentage of Clarifier TSS that is part of the total TSS of the input slurry. This equation was developed using the same approach used to develop Equations 1 and 2. To simplify the equation, it was developed at a fixed water to pozzolan ratio of 0.42.

EQUATION 3

Output Specific Gravity = BCD(6.05E-5) - CD(6.009E-5) - BC(4.97064E-2) + C(5.00935E-2) - BD(4.581E-5) + D(4.28289E-5) + B(3.28466E-1) + 5.34832E-1

where	**B**	**=**	**Specific Gravity of Pozzolans**
	C	**=**	**Specific Gravity of Input Slurry**
	D	**=**	**% of Clarifier TSS that is part of Total TSS**

The output specific gravity set-point computed by either Equations 1, 2, or 3 will be entered into the Automatic Density Controller of the RCM for process operations. The bases for derivation of these equations are included in Attachment G.

A correction factor for air entrapment will have to be applied to the computed value as explained in the next section.

5.3.5 Adjustment for Entrapped Air

Mixing in the RCM introduces air into the cement slurry. This entrapped air can be measured using a pressurized mud balance, which effectively measures the specific gravity of the slurry after squeezing out all the entrapped air. The air introduced into the slurry by the RCM will be measured occasionally to set the correction factor to compute the actual output specific gravity set-point.

For instance, for a product with 5% entrapped air,

Actual Sp. Gr. Set-point = Calculated Specific Gravity Set-point ÷ 1.05

The amount of entrapped air in the product is not expected to vary significantly during the process. It is recommended that the test to measure entrapped air be measured once every batch. If there is no significant variation in this value from batch to batch, the measurement can be reduced to once every operating day.

It is also possible that due to the intense agitation performed at the batch tanks, air might be introduced into the input slurry. This would have to be determined during the hot test and might result in the application of a correction factor to the input slurry specific gravity.

5.3.6 Sensitivity of Control

The critical parameter on which the entire process is controlled is the specific gravity of the output product. This output specific gravity is sensitive to the usual factors such as measurement and instrumentation. In addition, the two parameters that have the most critical bearing on the product specific gravity are:

- specific gravity of solids in the waste (dissolved and suspended)

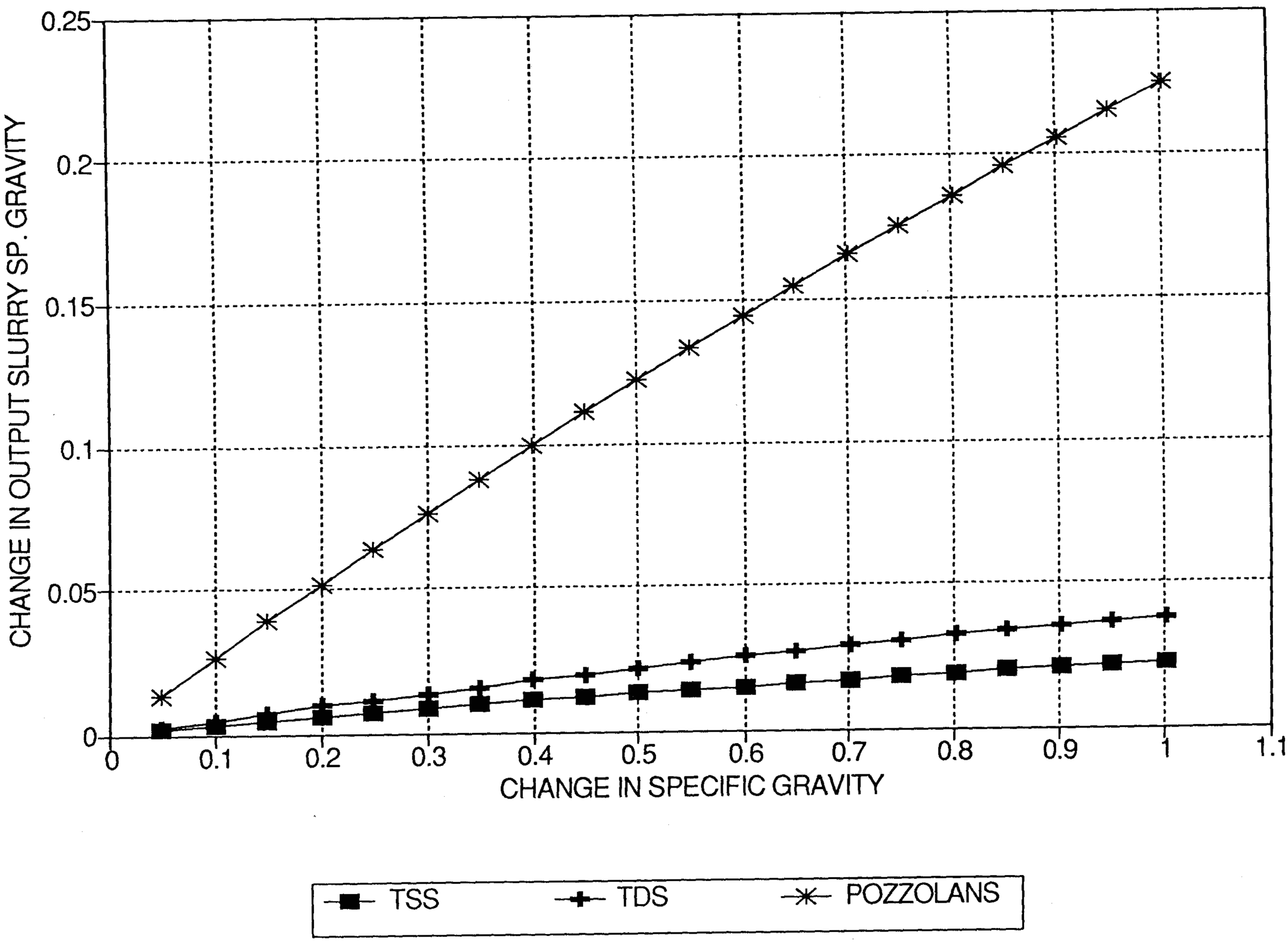
- specific gravity of the pozzolans.

The specific gravity of the solids in the waste is not a parameter that can be subjected to external control, while that of the pozzolans added to the mix is. In this context, a sensitivity analysis was conducted to examine the dependence of the output product specific gravity on the two parameters.

Figure 5-6 shows the impact of the change in specific gravity of the TSS, TDS and the Pozzolans when the Pond 207C waste is stabilized. For purposes of this example, a 30% TDS, 10% TSS slurry was combined with the pozzolans at a water to pozzolan ratio of 0.42. As can be seen, the impact of specific gravity variations in the TSS and TDS of the waste are almost negligible while that of the Pozzolans is quite substantial.

This means that the process is insensitive to wide variations of the input slurry contents as long as the upper limits of TSS and TDS are maintained. It also shows that the pozzolan specific gravity has to be measured for each delivery to RFP in order to compute the output specific gravity set-point. The calculations described above were at a fairly high solids loading; the process would be even less sensitive to specific gravity variations in the input waste components (TSS and TDS) at lower solids loadings.

Figure 5-6 IMPACT OF SP. GRAVITIES OF
INPUT COMPONENTS ON OUTPUT SP. GRAVITY



6.0 CONCLUSIONS

The objective of the treatability study was to develop a CSS formula for Pond 207C and the Clarifier such that the final solidified waste meets all necessary regulatory requirements for ultimate land disposal at the Nevada Test Site. The regulatory requirements include all federal and state regulations governing hazardous wastes and the requirements in the "Nevada Test Site Defense Waste Acceptance Criteria, Certification, and Transfer Requirements," NVO-325, for low-level mixed waste.

The primary regulatory requirements evaluated during the treatability study included treatment standards for the Land Disposal Restrictions (LDR) as regulated by 40 CFR Part 268, and the treatment standards for RCRA characteristic wastes for toxicity as regulated by 40 CFR Part 261. The hazardous waste codes that are applicable to Pond 207C and the Clarifier include F001, F002, F003, F005, F006, F007, F009, D004, D006, and D007 (D004 and D007 are only applicable to Pond 207C water). Additionally, testing was conducted to verify that the solidified waste had no free liquids after a 28-day cure and that the solidified material would be considered a solid in accordance with Department of Transportation requirements.

Another goal of the treatability study was to provide analytical data that meets a data quality objective (DQO) equivalent to CLP level IV, which is considered to be legally defensible. All of the analytical testing that was necessary for NTS acceptance was performed at DQO level IV. This data was also validated, which is an independent quality assurance check of the laboratory results.

Additional testing conducted on the stabilized waste included freeze/thaw and wet/dry durability testing. These tests were conducted to evaluate the effects of variations in the environment on the stabilized waste. Evaluation of these criteria were considered because of the possibility that the material will be stored at Rocky Flats for a significant time period before ultimate disposal at NTS.

6.1 Conclusions for Pond 207C

The conclusions stated in this section are based on the testing conducted during the treatability study.

Chlorination

Disinfection of Pond 207C waste is required for eventual certification of the stabilized waste form.

All Pond 207C waste material was chlorinated using 2000 ppm of calcium hypochlorite prior to solidification. The use of 2000 ppm of calcium hypochlorite for disinfection will provide in excess of 1 ppm of residual chlorine after 30 minutes which is a typical requirement for sewage wastewater disinfection. Additionally, the blending of pozzolans with the waste streams will increase the pH of the mixture to above 12.0 S.U., which will provide further disinfection. The combination of the calcium hypochlorite and the pH condition of greater than 12.0 S.U. should provide adequate disinfection of any pathogens that may have been present from past discharges of sewage sludge to the solar ponds.

CSS Binder Formulation

The selected CSS binder formulation for Pond 207C slurry includes Type V Portland cement, Type C flyash, plus hydrated lime. Testing also evaluated the use of the Halliburton Services Latex 2000 System to determine if its use would improve durability performance. Formulations with or without the addition of Latex meet all of the regulatory acceptance criteria (LDR standards and free liquid testing) therefore, the addition of Latex is not required to meet these criteria. The addition of Latex appears to produce a final product which has better resistance to the wet/dry and freeze/thaw durability testing based on observations from the petrographic analysis. Cylinders with dosages of 3 and 5 percent latex (by weight of the cement) had less crystal growth, less microcracks, and better cement hydration compared to cylinders prepared without the latex.

Pozzolan Blend

The selected CSS formulation of cement, flyash, and lime is a weight ratio of 1.0/2.0/0.075. Testing indicated that the CSS formulation is not extremely sensitive to the ratio of these components, which can vary from 1.0/1.2/0.05 to 1.0/3.34/0.09 and still successfully achieve all regulatory criteria and NTS acceptance criteria.

Water to Pozzolan Ratio

Testing was successful on water to pozzolan ratios which varied from 0.34 to 0.56. The mixes prepared at these water to pozzolan ratios passed all certification criteria (LDR compliance and no free liquids) and performed adequately in the durability testing. For the treatability testing, pozzolan was defined as the sum of cement and flyash. During remediation, a slight variation in the water to pozzolan ratio will be required to account for the lime portion in the pozzolan blend.

Waste Loading

The waste loading parameters of concern were total solids, total dissolved solids, and total suspended solids. Testing on waste with total solids that varied from 35.0 to 49.1 percent, total dissolved solids that varied from 27.3 to 40.4 percent, and total suspended solids that varied form 0.89 to 17.2 percent successfully passed all regulatory criteria and performed adequately in the durability testing. These parameters must be considered in conjunction with each other, and are not independent of one another. During remediation, it will be necessary to monitor these parameters to assure that the maximum concentrations which were tested in the treatability study are not exceeded during waste processing. The treatability study results indicate that the CSS formulation will produce a final product which meets all regulatory requirements if the waste loadings are maintained within the above ranges.

Process Control Philosophy

The key process control parameters during the treatability testing were total solids, total dissolved solids, total suspended solids, and water to pozzolan ratio. The relationships between these parameters have been depicted graphically in Figures 3-1 to 3-4. To ensure that the solidified waste product can be certified, waste processing must comply with the conditions shown in Figures 3-1, 3-2, 3-3, and 3-4.

During remediation, the process will be controlled by monitoring the input and output slurry specific gravities. The input specific gravity corresponds to a total solids and water content, which at a specified water to pozzolan ratio, determines the required specific gravity of the output. The nuclear densometer on the RCM continuously monitors the output specific gravity and makes any necessary adjustments to the pozzolan feed to maintain the output specific gravity to within 1% of the set point.

Regulatory Compliance

Based on the analytical results from the treatability study, it is concluded that if the treatment process is operated within the stated conditions for chlorination, CSS binder formulation, water to pozzolan ratio, and waste loading, then the final solidified waste should comply with all acceptance criteria. The acceptance criteria include the following:

- Pass all LDR requirements for F001, F002, F003, F005, F006, F007, and F009 listed wastes as regulated by 40 CFR Part 268.
- Pass the requirements for characteristic wastes by toxicity for D004, D006, and D007 as regulated by 40 CFR Part 261.
- The final waste form shall be considered a solid as determined by the Standard Test Method for Determining Whether a Material is a Liquid or a Solid (ASTM D4359-84).
- The final waste form should have no free liquids as determined by the Paint Filter Liquids Test (SW846, Method 9095).
- The final waste form should achieve acceptable strength as measured by unconfined compressive strength (UCS).
- The final waste form should be adequately disinfected.

6.2 Conclusions for Pond 207C and Clarifier

The conclusions stated in this section are based on the testing conducted during the treatability study.

Chlorination

Disinfection of Pond 207C and clarifier waste is required for eventual certification of the stabilized waste form.

All Pond 207C and clarifier waste material was chlorinated using 2000 ppm of calcium hypochlorite prior to solidification. The use of 2000 ppm of calcium hypochlorite for disinfection will provide in excess of 1 ppm of residual chlorine after 30 minutes, which is a typical requirement for sewage wastewater disinfection. Additionally, the blending of pozzolans with the waste streams will increase the pH of the mixture to above 12.0 S.U., which will provide further disinfection. The combination of the calcium hypochlorite and the pH condition of greater than 12.0 S.U. should provide adequate disinfection of any pathogens that may have been present from past discharges of sewage sludge to the solar ponds.

CSS Binder Formulation

The selected CSS binder formulation for the Pond 207C and clarifier waste stream includes Type V Portland cement, Type C flyash, and hydrated lime. Testing also evaluated the use of the Halliburton Services Latex 2000 System to determine if its use would improve durability performance. Formulations with or without the addition of Latex meet all of the regulatory acceptance criteria (LDR standards and free liquid testing), therefore, the addition of Latex is not required to meet these criteria. The addition of Latex appears to produce a final product which has better resistance to the wet/dry and freeze/thaw durability testing based on observations from the petrographic analysis. Cylinders with dosages of 3 and 5 percent latex (by weight of the cement) had less crystal growth, less microcracks, and better cement hydration compared to cylinders prepared without the latex.

Pozzolan Blend

The selected pozzolan blend for cement, flyash, and lime is a weight ratio of 1.0/2.0/0.075. Testing indicated that the CSS formulation is not extremely sensitive to the pozzolan blend, which can vary from 1.0/0/0.022 to 1.0/2.0/0.077 and still successfully achieve all regulatory criteria and NTS acceptance criteria.

Water to Pozzolan Ratio

Testing was successful on water to pozzolan ratios which varied from 0.34 to 0.50. The mixes prepared at these water to pozzolan ratios passed all certification criteria (LDR compliance and no free liquid) and performed adequately in the durability testing. For the treatability testing, pozzolan was defined as the sum of cement and flyash. During remediation, a slight variation in the water to pozzolan ratio will be required to account for the lime portion in the pozzolan blend.

Waste Loading

The waste loading parameters of concern during the treatability study were total solids, total dissolved solids, and total suspended solids. Testing on waste with total solids that varied from 33.8 to 38.9 percent, total dissolved solids that varied from 27.7 to 34.6 percent, and total suspended solids that varied from 11.0 to 11.6 percent successfully passed all regulatory criteria and performed adequately in the durability testing. Additionally, the maximum suspended solids contribution from the clarifier is 5.7 percent. These parameters must be considered in conjunction with each other, and are not independent of one another. During remediation it will be necessary to monitor these parameters to assure that the maximum concentration which were tested in the treatability study are not exceeded during waste processing. The treatability study results indicate that the CSS formulation will produce a final product which meets all regulatory requirements if the waste loadings are maintained within the above ranges.

Process Control Philosophy

The key control parameters during the treatability study were total solids, total dissolved solids, total suspended solids, and water to pozzolan ratio. The relationships between these parameters have been depicted graphically in Figures 3-5 to 3-8. To ensure that the solidified waste product can be certified, waste processing must comply with the conditions shown in Figures 3-5, 3-6, 3-7, and 3-8.

During remediation the process will be controlled by monitoring the input and output slurry specific gravities. The input specific gravity corresponds to a total solids and water content, which at a specified water to pozzolan ratio, determines the required specific gravity of the output. The nuclear densometer on the RCM continuously monitors the output specific gravity and makes any necessary adjustments to the pozzolan feed to maintain the output specific gravity to within 1% of the set point.

Regulatory Compliance

Based on the analytical results from the treatability study, it can be concluded that if the treatment process is operated within the stated conditions for chlorination, CSS binder formulation, pozzolan blend, water to pozzolan ratio, and waste loading, then the final solidified waste should comply with all acceptance criteria. The acceptance criteria include the following:

- Pass all LDR requirements for F001, F002, F003, F005, F006, F007, and F009 listed wastes as regulated by 40 CFR Part 268.

- Pass the requirements for characteristic wastes by toxicity for D004, D006, and D007 as regulated by 40 CFR Part 261.

- The final waste form should be considered a solid as determined by the Standard Test Method for Determining Whether a Material is a Liquid or a Solid (ASTM D4359-84).

- The final waste form should have no free liquids as determined by the Paint Filter Liquids Test (SW846, Method 9095).

- The final waste form should achieve acceptable strength as measured by unconfined compressive strength (UCS).

- The final waste form should be adequately disinfected.

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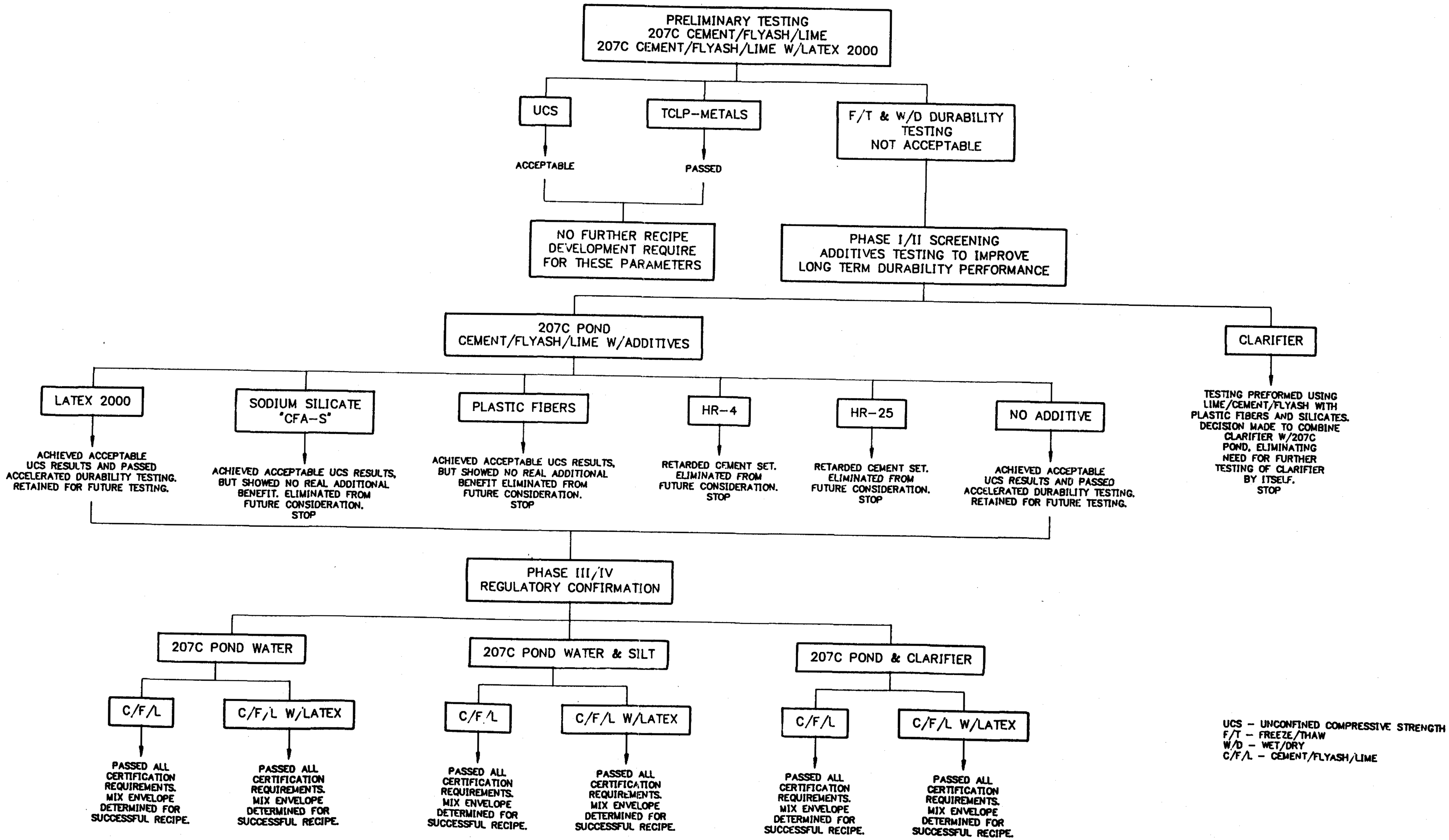

FIGURE 2-1

POND 207C/CLARIFIER TREATABILITY STUDY LOGIC DIAGRAM
ROCKY FLATS, GOLDEN, COLORADO

Deliverable (Combined) 235A and 235B
POND 207C AND CLARIFIER
TREATABILITY STUDY REPORT

HALLIBURTON NUS Environmental Corporation